HAGER-RICHTER
GEOSCIENCE, INC.

BOREHOLE GEOPHYSICAL LOGGING
CABO ROJO GROUNDWATER CONTAMINATION SITE
CABO ROJO, PUERTO RICO

Prepared for:

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File 13RG03
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File 13RG03

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RE: Borehole Geophysical Logging
Cabo Rojo Groundwater Contamination Site
Cabo Rojo, Puerto Rico

Dear Ms. Schofield:

In this report, we present the results of borehole geophysical logging conducted by Hager-Richter Geoscience, Inc. (Hager-Richter) at the Cabo Rojo Groundwater Contamination Site (Site) located in Cabo Rojo, Puerto Rico for CDM Smith (CDM) in August, 2013. The borehole geophysical logging program was conducted as part of an ongoing Remedial Investigation / Feasibility Study (RI/FS) at the Site by CDM under work assignment 045-RICO-A244 for the United States Environmental Protection Agency (EPA). The scope of work for the borehole geophysical logging reported herein was specified by CDM.

Introduction

The Cabo Rojo Groundwater Contamination Site is located in the Bajura ward in the municipality of Cabo Rojo in southwestern Puerto Rico. The locations of the logged boreholes are shown in Figure 1. According to information provided by CDM, the Site is currently defined as a groundwater plume with no identified source(s) of contamination. Groundwater samples collected from the Cabo Rojo Urbano public water system from 2004 to 2010 indicated that the PCE and TCE were detected in several public water supply wells.

CDM requested borehole geophysical logging as part of the ongoing RI/FS of the Site. CDM was interested in determining the depth and orientation (dip azimuth and dip angle) of bedrock fractures intersected by the logged boreholes and depths where water flows into and out of the boreholes under ambient and stressed (low constant rate pumping) conditions.

Borehole geophysical logging was conducted in three (3) boreholes in August, 2013; one (1) newly installed borehole identified as MW-9R and two (2) existing water supply wells identified as Ana Maria and Pozo Escuela. The logged boreholes were cased through the overburden with steel casing and were open-hole throughout the bedrock portions of the boreholes. The date logged, casing depth, open-hole interval, open bedrock diameter, and water level for each of the logged boreholes are reported in Table 1. The datum for depths in this report is ground surface at the location of each borehole.

Table 1 - Borehole Information

<table>
<tr><th>Borehole
(Date Logged)</th><th>Bottom
of Casing
(feet)</th><th>Open-Hole
Interval
(feet)</th><th>Open
Bedrock
Diameter</th><th>Water
Level
(feet)</th></tr>
<tr><td>MW-9R
(August 19, 2013)</td><td>104.8</td><td>104.8 - 190.8</td><td>approx. 4 inches</td><td>16.0</td></tr>
<tr><td rowspan="2">Ana Maria
(August 21, 2013)</td><td rowspan="2">58.4</td><td>58.4 - 105.0</td><td>approx. 10-12 inches</td><td>12.6</td></tr>
<tr><td colspan="3">Ana Maria was expected to be open to a depth of
204 feet, but the borehole was blocked at 105 feet.</td></tr>
<tr><td>Pozo Escuela
(August 20, 2013)</td><td>39.0</td><td>39.0 - 191.2</td><td>approx. 9-11 inches</td><td>10.3</td></tr>
</table>

The borehole geophysical logging program consisted of:

- Optical Televiewer (OTV)
- Acoustic Televiewer (ATV)
- Acoustic Caliper
- Fluid Temperature
- Fluid Resistivity
- Heat Pulse Flow Meter (HPFM) under ambient and pumping conditions

In addition to the borehole geophysical logging, Hager-Richter also conducted wireline fluid sampling in the three logged boreholes (MW-9R, Ana Maria, and Pozo Escuela) and four additional boreholes identified as MW-3R, MW-3RS, TCP, and Club de Leones. The locations of the boreholes that were wireline fluid sampled are shown in Figure 1. Hager-Richter was responsible for conducting the wireline fluid sampling and for providing CDM with a one-liter sample at each of the sampling depths. CDM was responsible for taking the samples from Hager-Richter, providing the sample bottles, filling the sample bottles, completing the paperwork, and shipping the samples.

According to information provided by CDM, the wireline fluid sampling was conducted to collect screening-level volatile organic compound (VOC) data in groundwater at discrete depths for CDM to evaluate the vertical distribution of contamination for use in site characterization and monitoring well design. In the three logged boreholes (MW-9R, Ana Maria, and Pozo Escuela), fluid sampling depths were selected on-site by Hager-Richter and CDM. Sampling depths were selected based on water entry points identified from the borehole geophysical logging data acquired by Hager-Richter. The fluid sampling depths in the additional four boreholes (MW-3R, MW-3RS, TCP, and Club de Leones) were specified by CDM prior to Hager-Richter's mobilization to the Site.

Objectives

The objectives of the borehole geophysical logging program were to determine the depth and orientation (dip azimuth and dip angle) of bedrock fractures intersected by the boreholes and to determine depths where water flows into and out of the boreholes under ambient and pumping conditions. The objective of the wireline fluid sampling was to collect screening-level VOC data in groundwater at discrete depths for CDM to evaluate the vertical distribution of contamination for use in site characterization and monitoring well design.

Field Operations

Robert Garfield and Nicholas DeCristofaro of Hager-Richter conducted the field operations August 19-23, 2013. The project was coordinated with Ms. Susan E. Schofield and Ms. Frances Delano of CDM. Mr. José Reyes, also of CDM, was on-site during field operations. Data analysis and interpretation were completed at the Hager-Richter offices. Preliminary borehole geophysical logging results were provided to CDM electronically on August 20 and 22, 2013. Original data and field notes reside in the Hager-Richter files and will be retained for at least three years.

Equipment

General. A Mount Sopris Matrix portable digital logging system was used with a 4MXA-1000 winch for the borehole geophysical logging. Data were recorded in digital format using a PC. Data were displayed in real time in the field and were processed in the office using WellCAD v4.4, commercially licensed software.

Optical Televiewer. An ALT OBI-40 optical televiewer (OTV) probe was used for this project. The OTV acquires a high resolution, effectively continuous, magnetically oriented, 360° image of the borehole wall. The image can be used to detect bedrock structures such as fractures, foliation, and bedding and to provide information about lithology. The probe includes a 3-axis magnetometer and three accelerometers to orient the image and to provide borehole deviation data that are used to correct structure orientations from apparent to true orientations.

Acoustic Televiewer. An ALT ABI-40 acoustic televiewer (ATV) probe was used for this project. The ATV acquires a high resolution, effectively continuous, magnetically oriented, 360° image of the borehole wall using the reflected signal of sound waves in the ultrasonic frequency range. Both amplitude and travel time of the reflected signal are recorded and can be used to detect bedrock structures such as fractures, foliation, and bedding. The probe includes a 3-axis magnetometer and three accelerometers to orient the image and to provide borehole deviation data that are used to correct structure orientations from apparent to true orientations.

ATV travel time data can also be used to calculate an acoustic caliper log. The acoustic caliper log measures the average borehole diameter as a function of depth. The acoustic caliper log is derived from the travel time data and the velocity of the acoustic signal in water. The acoustic caliper log is used to locate fractures and to aid in the interpretation of other borehole geophysical logs.

Fluid Temperature. A Mount Sopris 40FTC-1000 fluid resistivity/temperature probe was used for the temperature logging. The temperature sensor is a semiconductor device for which the voltage output is linearly related to temperature. Temperature logs record the temperature of the borehole fluid with depth and are useful for detecting flow into or out of a borehole. If fluid temperature contrasts are present between the borehole fluid and individual fractures and fracture zones, the fluid temperature logs are also useful indicators of flow into and out of the borehole.

Fluid Resistivity. A Mount Sopris 40FTC-1000 fluid resistivity/temperature probe was used for the fluid resistivity logging. The probe uses an electrically shielded Wenner array to measure the capacity of the borehole fluid to transmit electric current with depth and can be an indicator of salinity and water quality. If fluid resistivity contrasts are present between the borehole fluid and individual fractures and fracture zones, the fluid resistivity logs are also useful indicators of flow into and out of the borehole.

Resistivity is the physical property that relates electric current density to potential gradient and is defined as:

$$ñ = (A / L) * (V / I) \qquad \text{Eq. 1}$$

where:	ñ	is resistivity
	A	is cross-sectional area of a homogeneous tube
	L	is length of the tube
	V	is potential
	I	is current

Heat Pulse Flow Meter. A Mount Sopris HFP-2293 heat pulse flow meter (HPFM) was used for the HPFM logging. The HPFM measures the vertical rate and direction of fluid flow in a borehole at discrete depths and is designed to be used for boreholes with flow rates less than one gallon per minute (gpm). A heating grid heats a thin sheet of water in a short time interval (less than 0.05 seconds), and, if vertical flow is present, the sheet of water moves along the borehole in the direction of flow. Temperature sensors located at known distances above and below the heating grid monitor the differential temperature of the borehole fluid. The time required for the sheet of heated water to reach one of the sensors is measured, and, based on factory calibrations, the time is used to calculate the vertical flow rate. Depths where water flows into and out of the borehole can be interpreted based on changes in the vertical flow rate and/or direction. HPFM measurements can be made under ambient and stressed (pumping or injection) conditions.

Measurement depths are selected based on information provided by other borehole geophysical data such as OTV, ATV, fluid temperature, and fluid resistivity data. To make a measurement, the probe is positioned at a selected depth and the probe is stabilized by the friction between the centralizers and diverter petal on the probe and the borehole wall. When the borehole fluid has stabilized after the disturbance caused by the probe being moved to the measurement depth, the heating grid is fired, and a measurement cycle starts.

Wireline Fluid Sampler. A Mount Sopris 2FSA-1000 fluid sampler was used for the wireline fluid sampling. The fluid sampler takes one-liter fluid samples at discrete depths. The borehole geophysical logging winch and encoder are used to lower the fluid sampler to a specified depth. The fluid sample chamber is then electrically opened and left open for one minute, which allows the one-liter chamber in the fluid sampler to fill with water from the borehole at the specified sampling depth. The chamber is then closed before the probe is removed from the borehole. Air and water-tight valves on the probe ensure that the sample remains under pressure and that there is no air in the sample chamber. At the surface, the one-liter sample is removed from the fluid sampler probe through a valve at the bottom of the probe.

Limitations of the Methods

General. With the 4MXA-1000 winch, the logging cable passes over a calibrated wheel, and an encoder counts the revolutions, which are converted to depth. Slippage of the logging cable may occur, resulting in errors in recorded depth. At the beginning and end of a logging run, fiducial depths (commonly ground surface or top of casing) are measured and are compared to determine if slippage occurred.

Optical Televiewer. The OTV logs can be acquired in both air and optically clear water-filled boreholes. If the borehole is water-filled, the clarity of the water directly affects the quality of the OTV image. The OTV probe must be centralized in the borehole to acquire optimal images of the borehole wall. If the borehole wall is rough and/or irregular or the diameter of the open borehole is larger than the diameter of the casing, the probe may not be adequately centralized and the quality of the optical images may be compromised.

The OTV logs are used to determine the depth and orientation of fractures and other planar features intersected by a borehole. In some cases, natural planar features in the bedrock, such as mineral veins, bedding, and foliation may appear to be fractures in the OTV logs, but are not actual discontinuities in the bedrock. The OTV images are also used to provide information about lithology.

The accuracy of the orientation measured by the OBI-40, as stated by the manufacturer, is ±0.5° for the inclination data and ±1° for the azimuth data. The OBI-40 relies on the earth's magnetic field to determine azimuth. Therefore, in areas where the magnetic field may be significantly affected by local magnetic objects, the dip azimuths reported in the logs may be compromised. Specifically, the dip azimuth of bedrock structures and the borehole deviation data within approximately five feet of steel casing are not accurate.

Acoustic Televiewer. ATV logging requires that liquid be present in the portion of the borehole to be logged. However, the liquid does not need to be optically clear. The ATV probe must be centralized in the borehole to acquire optimal images of the borehole wall. If the borehole wall is rough and/or irregular or the diameter of the open borehole is larger than the diameter of the casing, the probe may not be adequately centralized and the quality of the acoustic images may be compromised.

The ATV logs are used to determine the depth and orientation of fractures and other planar features intersected by a borehole. In some cases, natural planar features in the bedrock, such as mineral veins, bedding, and foliation may appear to be fractures in the ATV logs, but are not actual discontinuities in the bedrock.

The accuracy of the orientation measured by the ABI-40, as stated by the manufacturer, is ±0.5° for the inclination data and ±1° for the azimuth data. The ABI-40 relies on the earth's magnetic field to determine azimuth. Therefore, in areas where the magnetic field may be significantly affected by local magnetic objects, the accuracy of dip azimuths reported in the logs may be reduced. Specifically, the dip azimuth data of bedrock structures and the borehole deviation data within approximately five feet of steel casing are not accurate.

Fluid Temperature. Fluid temperature logging requires that liquid be present in the portion of the borehole to be logged. According to the manufacturer's specifications, the measurement range is -20°C to 80°C, the accuracy is better than ±1%, and the resolution is 0.01° C. Temperature logging is ineffective for accurately measuring the formation fluid temperature unless the borehole fluid is at equilibrium, except for detecting flow into or out of the borehole via hydraulically transmissive fractures. Additionally, a vertical temperature gradient must be present in the borehole in order to detect water movement into or out of the borehole.

Fluid Resistivity. Fluid resistivity logging requires that liquid be present in the portion of the borehole to be logged. According to the manufacturer's specifications, the measurement range is 0 ohm-m to 100 ohm-m, the accuracy is better than ±1%, and the resolution is 0.05%. A contrast in fluid resistivity must be present between the borehole fluid and fluid in the fractures in order to detect water movement into or out of the borehole.

Heat Pulse Flow Meter. The HPFM requires liquid in the interval to be logged. According to the manufacturer's specifications for the HPFM, the measuring range is 0.03 to 1.0 gpm, the accuracy is ±5% for the mid-range, increasing to ±15% for the extremes of the range, and the resolution is 5%. Data below the stated calibration range are reported when such data are repeatable. Although the accuracy of such data may be low, non-zero values indicate that flow is occurring and indicate the direction of flow. The HPFM probe measures the difference in temperature between the upper and lower temperature sensors. In the absence of flow, the thermal pulse would move symmetrically out from the grid, affecting the two sensors equally as a function of time. Therefore, the conductive or convective dissipation of the heat pulse would yield a zero value in the absence of flow.

Wireline Fluid Sampler. Samples can only be taken when the probe is fully submerged in the borehole fluid. The probe can only hold a one-liter sample and the fluid sampler valves must be maintained to ensure that there is no leakage into our out of the sample chamber while logging.

Field Procedures & Data Acquisition

Adequate tension was maintained with the logging cable during the borehole geophysical logging and wireline fluid sampling to ensure contact between the logging cable and the depth encoder. The depth encoder was cleaned after each logging run in order to maintain accurate depth measurements. Repeat sections for each log were acquired to verify depth consistency. In addition, at the beginning and end of a logging run, a fiducial depth (top of casing or ground surface) was measured and checked for consistency. Recorded depths of fixed features in the borehole (i.e. reported casing lengths and reported borehole depths) were also checked for depth consistency.

The borehole geophysical logging sequence and the data acquisition parameters for the logged boreholes are reported in Table 2.

Table 2 – Borehole Geophysical Logging Sequence & Data Acquisition Parameters

Log	Sampling Interval	Logging Speed	Logging Direction
1. Fluid Temperature & Fluid Resistivity	0.10 feet	10 feet/minute	down & repeat up
2. OTV	0.01 feet	5 feet/minute	down
3. ATV& Acoustic Caliper	0.01 feet	8 feet/minute	down & repeat up
4. HPFM under ambient conditions	HPFM data were acquired at discrete depths under ambient conditions.		
5. HPFM under pumping conditions	HPFM data were acquired at discrete depths while water was pumped from each borehole at a low constant rate.		
6. Wireline Fluid Sampling	Fluid samples were taken at discrete depths specified by CDM.		

To ensure reliable HPFM measurements, the borehole water level was monitored and recorded throughout the HPFM testing. For the HPFM logging under pumping conditions, water was pumped from the logged boreholes from within the casing at a low constant rate under one gpm. The pump rate was monitored at the time of logging with a rotameter to ensure a constant pumping rate throughout the HPFM logging. HPFM measurements under pumping conditions were not started until there was little to no water draw-down in the borehole being pumped. This procedure ensures that the stress from pumping is generating water from hydraulically transmissive fractures and not from borehole storage, water stored in the well-bore.

The cable and downhole probes were decontaminated prior to first use and after logging each borehole. The wireline fluid sampler and sample chamber were decontaminated prior to first use and after each sample was collected. The cable and probes were decontaminated by rinsing with an Alconox and water solution followed by rinsing with water, which was provided by CDM from a screened water source. Following the water rinse, the cable, probes, and fluid sample chamber were rinsed with deionized water.

Data Processing

The processing consists mainly of selecting scales, filters, and the layout of the tracks. In addition, the OTV and ATV data require determining the depth, orientation, and category of the bedrock structures detected. To increase the quality of the OTV images, the brightness and contrast of the images were adjusted. To increase the quality of the images, the ATV travel time images were digitally centralized. The ATV amplitude images can be normalized, although normalization was not applied to the ATV amplitude data for this project.

Data Interpretation & Presentation

Bedrock Fracture Interpretation & Presentation. Fractures can be identified on the basis of the OTV images, ATV amplitude images, and ATV travel time images. Some, if not most, of the criteria for identifying fractures based on the OTV and ATV data require a judgment call, and different log analysts will not necessarily make the same call. Hence, some of the bedrock structures identified as fractures may not be fractures. Bedding, foliation, veins, and other planar geologic features in the bedrock may appear similar to fractures in the borehole geophysical data.

The datum for depths in this report is the ground surface at the location of each borehole. The depths of bedrock structures are reported as the average depth of the top and bottom intersections of each bedrock structure and the borehole wall. The orientations of bedrock structures (fractures, bedding, foliation, veins, and other planar geologic features) are reported as the dip azimuth (dip direction) and dip angle of each structure. The dip azimuth is perpendicular to strike as used commonly by geologists. The televiewer logs and the fracture dip azimuth data are referenced to true north using a magnetic declination of 12° west as specified by CDM. The fracture dip angle data are reported relative to horizontal.

Bedrock structures detected in the televiewer logs are grouped into three categories: Fracture Rank 1, Fracture Rank 2, and Fracture Rank 3. The categories are shown as color-coded lines and symbols on the structure projection plots, tadpole plots, and on the structure statistics plots. Figure 2 explains the bedrock structure categories and Figure 3 explains how to read the tadpole plots.

Fracture Rank 1 describes minor fractures that are not distinct and may not be continuous around the borehole. Fracture Rank 2 describes intermediate fractures that are distinct and continuous around the borehole with little to no apparent aperture. Fracture Rank 3 describes major fractures that are distinct and continuous around the borehole with apparent aperture.

The structure projection plots, sinusoidal curves in the log track labeled Structure Projection, display the depth, orientation, and category of the bedrock structures detected in the televiewer data. Bedrock structures are essentially planar for short distances such as the intersection of the open borehole and the bedrock structure. The intersection of a plane, the bedrock structure, with a cylinder, the borehole, is a circle on the plane. When the circle is unwrapped and plotted as it is in the structure projection plots, the circle plots as a sine curve as shown in Figure 4. The orientations of structures plotted in the structure projection plots are referenced to magnetic north. The structures plotted in the structure projection plots are not corrected for borehole deviation. Therefore, the orientation of the structures are referred to as *apparent* orientations (that is, *apparent* dip angle and *apparent* dip azimuth). The true orientations (that is, *true* dip angle and *true* dip azimuth) of the detected bedrock structures are shown in the log track labeled Tadpole Plot. The correction from apparent to true orientation is made using the borehole deviation data acquired by the televiewer probes (OTV and ATV probes).

The tadpole plots are created from the structure projection plots after the data are corrected from apparent to true dip azimuth and dip angle as previously discussed. The tadpole plots graphically display the depth, orientation, and category of the bedrock structures interpreted from the televiewer images. The orientations of bedrock structures are graphically displayed on the tadpole plots by a tadpole consisting of a circle, the head, and a line, the tail. The position of the head, left to right on the tadpole plot, gives the dip angle of the bedrock structure. The left side of the track indicates a dip angle of 0° and the right side of the track indicates a dip angle of 90° from horizontal. The position of the tail gives the dip azimuth of the fracture and can be read like a compass. The tail pointing directly up is 0°, north. We note explicitly that dip azimuth is perpendicular to strike as the term is used by geologists.

Borehole Flow. The interpretation of flow under ambient and pumping conditions in the logged borehole is based on the fluid temperature, fluid resistivity, and HPFM data. Fluctuations in fluid temperature and fluid resistivity data indicate depths of possible flow into or out of the boreholes. Changes in the flow rate and/or direction in the HPFM data also indicate depths of flow into or out of the boreholes. It is possible to calculate the flow rate, in gallons per minute (gpm), and flow direction based on the HPFM data. Therefore, it is possible to differentiate between flow into and flow out of the boreholes based on the HPFM data. However, the fluid temperature and fluid resistivity data alone can only be used to determine depths of possible flow into or out of the boreholes. It is not possible to determine the flow rate, flow direction, or differentiate between flow into and flow out of the boreholes based on fluid temperature and fluid resistivity alone.

Flow into and out of a borehole in fractured bedrock primarily occurs through transmissive fractures intersected by the borehole. Since HPFM data are acquired at discrete depths, changes in the flow rate and/or direction are detected between a pair of HPFM measurement depths. Depths of flow into and out of the boreholes detected by the HPFM are further refined by consideration of the fluid temperature and fluid resistivity logs, and the bedrock fractures detected in the televiewer (OTV and ATV) logs in the depth zones between HPFM measurements points where a change in the flow rate and/or direction is detected.

Presentation of Borehole Geophysical Logs. Two sets of borehole geophysical logs are provided for each logged borehole:

1. Borehole Image Logs at a scale of 1-inch to 2-feet
2. Borehole Geophysical Logs at a scale of 1-inch to 5-feet

The different scales for the Borehole Image Logs and the Borehole Geophysical Logs are designed to enhance presentation of the specific data plotted in each log. The scale of 1-inch to 2-feet for the Borehole Image Logs provides a more detailed view of the high resolution OTV and ATV images, while the more compressed scales of 1-inch to 5-feet for the Borehole Geophysical Logs enable better interpretation of the linear data where anomalies may be subtle and take place over broad depth ranges.

The Borehole Image Logs consist of:

Track 1. OTV Image
Track 2. Depth in feet below the ground surface - scale at 1-inch to 2-feet
Track 3. ATV Amplitude
Track 4. ATV Travel Time & Structure Projection
Track 5. Acoustic Caliper & Tadpole Plot
Track 6. OTV Virtual Core
Track 7. Depth in feet below the ground surface - scale at 1-inch to 2-feet
Track 8. ATV Virtual Core

The Borehole Geophysical Logs consist of:

Track 1. OTV Image
Track 2. Depth in feet below the ground surface - scale at 1-inch to 5-feet
Track 3. ATV Amplitude
Track 4. ATV Travel Time
Track 5. Acoustic Caliper & Tadpole Plot
Track 6. Fluid Temperature & Fluid Resistivity
Track 8. Depth in feet below the ground surface - scale at 1-inch to 5
Track 8. HPFM under ambient & pumping conditions & Flow Comments

Results

General. The locations of the logged boreholes are shown in Figure 1. The borehole geophysical logs are given in Appendix 1, the bedrock structure statistics plots are given in Appendix 2, and the tables of bedrock structures are given in Appendix 3. The datum for depths in this report is the ground surface at the location of each borehole. The televiewer logs and fracture dip azimuth data are referenced to true north using a magnetic declination of 12°west. The fracture dip angle data are reported relative to horizontal.

Borehole geophysical logging was conducted in three (3) boreholes in August, 2013; one (1) newly installed borehole identified as MW-9R and two (2) existing water supply wells identified as Ana Maria and Pozo Escuela. The logged boreholes were cased through the overburden with steel casing and were open-hole throughout the bedrock portions of the boreholes. The date logged, casing depth, open-hole interval, open bedrock diameter, and water level for each of the logged boreholes are reported in Table 1.

Bedrock Fracture Results. The number of bedrock structures interpreted as fractures in the logged boreholes and the prominent orientations of the fractures detected in the logged boreholes are reported in Table 3 and are evident in the bedrock structure statistics plots in Appendix 2.

Table 3 – Summary of Bedrock Fracture Statistics

Borehole	Number of Fractures	Prominent Fracture Dip Azimuths	Prominent Fracture Dip Angles
MW-9R	73	northwest (285° - 300°) southeast (135° - 150°)	60° - 80° from horizontal
Ana Maria	59	northwest (285° - 300°) southeast (105° - 120°) south-southwest (180° - 195°)	15° - 50° from horizontal
Pozo Escuela	175	west (240° - 300°) east-southeast (90° - 105°)	45° - 60° from horizontal 0° - 5° from horizontal

Highly fractured and weathered bedrock was evident in Ana Maria from the bottom of casing at 58.4 feet to approximately 87 feet and in Pozo Escuela from the bottom of casing at 39.0 feet to approximately 58 feet. These highly fractured and weathered shallow bedrock zones caused irregularly shaped boreholes and sharp changes in borehole diameter. These conditions made it difficult to centralize the televiewer probes and to identify individual fractures within these highly fractured zones.

Borehole Flow Results. The borehole flow data (fluid temperature, fluid resistivity, and HPFM) are plotted on the borehole geophysical logs provided in Appendix 1. Depths of interpreted flow into and out of the boreholes are reported as text overlaid on the HPFM track (the last track to the right) on the borehole geophysical logs. The borehole flow conditions for each of the logged boreholes are reported in Tables 4-6.

Flow was not detected in borehole MW-9R with the HPFM under ambient conditions. Therefore, flow results in this report for MW-9R are based only on the HPFM data under pumping conditions as well as the fluid temperature and fluid resistivity data.

Table 4 - Summary of Borehole Flow in MW-9R

Depths (feet)	Comments
16.0	water level
27.0 - 29.0	location of the pump for HPFM logging under pumping conditions
29.0 - 83.1	flow up the borehole in the casing at 0.24 gpm under pumping conditions
104.8	bottom of casing
104.8 - 107.1	possible flow into or out of the borehole based on the fluid temp. & fluid res. data
107.1 - 124.6	flow up the borehole at 0.24 gpm under pumping conditions
124.6 - 126.2	flow into and up the borehole under pumping conditions
126.2 - 135.0	flow up the borehole at 0.18 gpm under pumping conditions
135.0 - 139.1	flow into and up the borehole under pumping conditions
139.1 - 165.2	flow up the borehole at 0.02 gpm under pumping conditions
165.2 - 168.3	flow into and up the borehole under pumping conditions
168.3 - 190.8	no flow detected
190.8	bottom of the borehole

The highly fractured and weathered shallow bedrock in Ana Maria and Pozo Escuela are both interpreted as hydraulically transmissive zones based on the HPFM results. It was not possible to determine individual flow pathways within each of these fracture zones as the fractures in each of these zones are interconnected and acting as a single hydraulic unit.

Table 5 - Summary of Borehole Flow in Ana Maria

Depths (feet)	Comments
12.6	water level
20.0 - 22.0	location of the pump for HPFM logging under pumping conditions
20.0 - 58.4	no flow detected in the casing under ambient conditions; flow up the borehole in the casing at 0.75 gpm under pumping conditions
58.4	bottom of casing
58.4 - 87.3	flow out of the borehole under ambient conditions; flow into and up the borehole under pumping conditions
87.3 - 90.8	flow up the borehole at 0.19 gpm under ambient conditions; flow up the borehole at 0.25 gpm under pumping conditions
90.8 - 96.2	possible flow into or out of the borehole based on the fluid resistivity data
96.2 - 105.0	flow up the borehole at 0.19 gpm under ambient conditions; flow up the borehole at 0.25 gpm under pumping conditions
105.0	the borehole was blocked at a depth or 105 feet at the time of logging; flow into and up the borehole from within or below the blockage under ambient and pumping conditions

Table 6 - Summary of Borehole Flow in Pozo Escuela

Depths (feet)	Comments
10.3	water level
20.0 - 22.0	location of the pump for HPFM logging under pumping conditions
20.0 - 39.0	no flow detected in the casing under ambient conditions; flow up the borehole in the casing at 0.75 gpm under pumping conditions
39.0	bottom of casing
39.0 - 58.4	flow out of the borehole under ambient conditions; flow into and up the borehole under pumping conditions
58.4 - 79.9	flow up the borehole at 0.60 gpm under ambient conditions; flow up the borehole at 0.31 gpm under pumping conditions
79.9 - 86.1	flow into and up the borehole under ambient and pumping conditions
86.1 - 87.2	flow up the borehole at 0.43 gpm under ambient conditions; flow up the borehole at 0.17 gpm under pumping conditions
87.2 - 95.0	flow into and up the borehole under ambient and pumping conditions
95.0 - 158.8	flow up the borehole at 0.05 gpm under ambient conditions; flow up the borehole at 0.01 gpm under pumping conditions
158.8 - 161.6	flow into and up the borehole under ambient and pumping conditions
161.6 - 191.2	no flow detected
191.2	bottom of the borehole

Wireline Fluid Sampling. Wireline fluid sampling was conducted in the three logged boreholes (MW-9R, Ana Maria, and Pozo Escuela) and four additional boreholes identified as MW-3R, MW-3RS, TCP, and Club de Leones. The approximate locations of the boreholes that were wireline fluid sampled are shown in Figure 1. Hager-Richter was responsible for conducting the wireline fluid sampling and for providing CDM with a one-liter sample at each of the sampling depths. CDM was responsible for taking the samples from Hager-Richter, providing the sample bottles, filling the sample bottles, completing the paperwork, and shipping the samples.

According to information provided by CDM, the wireline fluid sampling was conducted to collect screening-level VOC data in groundwater at discrete depths for CDM to evaluate the vertical distribution of contamination for use in site characterization and monitoring well design. In the three logged boreholes (MW-9R, Ana Maria, and Pozo Escuela), fluid sampling depths were selected on-site by Hager-Richter and CDM. Sampling depths were selected based on water entry points identified from the borehole geophysical logging data acquired by Hager-Richter. The fluid sampling depths in the additional four boreholes (MW-3R, MW-3RS, TCP, and Club de Leones) were specified by CDM prior to Hager-Richter's mobilization to the Site.

The fluid sampling was conducted at least two days after borehole geophysical logging or any other activities in each borehole. Fluid sampling was conducted under ambient conditions in boreholes MW-3R, MW-3RS, TCP, and Club de Leones as specified by CDM. For boreholes MW-9R, Ana Maria, and Pozo Escuela, the conditions for fluid sampling at each sample depth were based on the HPFM logging results from each borehole. If an inflow at a specific sampling depth was detected with the HPFM under ambient conditions, the fluid sampling at that depth was also conducted under ambient conditions. If an inflow at a specific sampling depth was only detected with the HPFM under pumping conditions, the sampling at that depth was also conducted at the same pumping rate used for the HPFM logging under pumping conditions in order to create the inflow detected during the HPFM logging.

For boreholes with multiple sampling depths, all of the ambient sampling in each borehole was conducted prior to the sampling conducted during pumping in each borehole due to the disturbance that would be created for the ambient samples while pumping. The fluid sampling was conducted from shallow to deep for the ambient sampling and then from sallow to deep for the sampling conducted during pumping to prevent disturbance of the deeper samples. The fluid sampling dates, times, depths, and sampling conditions are reported in Table 7.

Table 7 - Wireline Fluid Sampling

Borehole (Date Sampled)	Sampling Time	Sampling Depth (feet)	Sampling Condition (ambient or pumping)
MW-3R (August 21, 2013)	12:35 - 12:36 PM	93.4	ambient
MW-3RS (August 21, 2013)	1:07 - 1:08 PM	61.0	ambient
MW-9R (August 22, 2013)	12:26 - 12:27 PM	104.0	pumping
	12:55 - 12:56 PM	124.0	pumping
	1:31 - 1:32 PM	134.0	pumping
	2:04 - 2:05 PM	165.0	pumping
Ana Maria (August 23, 2013)	10:16 - 10:17 AM	100.0	ambient
	10:54 - 10:55 AM	58.0	pumping
	11:12 - 11:13 AM	70.0	pumping
	11:29 - 11:30 AM	91.0	pumping
Club de Leones (August 22, 2013)	9:00 - 9:01 AM	135.0*	ambient
	9:32 - 9:33 AM	95.0	ambient
	9:57 - 9:58 AM	105.0	ambient
	10:22 - 10:23 AM	115.0	ambient
	10:53 - 10:54 AM	125.0	ambient
Pozo Escuela (August 23, 2013)	8:03 - 8:04 AM	80.0	ambient
	8:23 - 8:24 AM	87.0	ambient
	8:44 - 8:45 AM	159.0	ambient
	9:03 - 9:04 AM	39.0	pumping
	9:20 - 9:21 AM	56.0	pumping
TCP (August 21, 2013)	2:20 - 2:21 PM	58.3	ambient

* The first sample taken in Club de Leones was the deepest sample as specified by CDM. Samples were planned at ten-foot intervals throughout the open bedrock in the borehole. The deepest sample was taken fist to use the fluid sampler to sound the bottom of the borehole to determine the total depth of the borehole in order to space the remaining sample depths at ten-foot intervals from the bottom of the borehole. After the sample at 135 feet, the remaining samples were taken from shallow to deep. The probe was lowered and raised for the sample at 135 feet at only five feet per minute to minimize disturbing the other sampling depths.

Limitations on the Use of this Report

This letter report was prepared for the exclusive use of CDM Smith (Client). No other party shall be entitled to rely on this Report or any information, documents, records, data, interpretations, advice or opinions given to Client by Hager-Richter Geoscience, Inc. in the performance of its work. The Report relates solely to the specific project for which Hager-Richter has been retained and shall not be used or relied upon by Client or any third party for any variation or extension of this project, any other project or any other purpose without the express written permission of Hager-Richter. Any unpermitted use by Client or any third party shall be at Client's or such third party's own risk and without any liability to Hager-Richter.

Hager-Richter has used reasonable care, skill, competence and judgment in the performance of its services for this project consistent with professional standards for those providing similar services at the same time, in the same locale, and under like circumstances. Unless otherwise stated, the work performed by Hager-Richter should be understood to be exploratory and interpretational in character and any results, findings or recommendations contained in this Report or resulting from the work proposed may include decisions which are judgmental in nature and not necessarily based solely on pure science or engineering. It should be noted that our conclusions might be modified if subsurface conditions were better delineated with additional subsurface exploration including, but not limited to, test pits, soil borings with collection of soil and water samples, and laboratory testing.

Except as expressly provided in this limitations section, Hager-Richter makes no other representation or warranty of any kind whatsoever, oral or written, expressed or implied; and all implied warranties of merchantability and fitness for a particular purpose, are hereby disclaimed.

If you have any questions or comments on this report, please contact us at your convenience. It has been a pleasure to work with CDM Smith on this project. We look forward to working with you again in the future.

Sincerely yours,
HAGER-RICHTER GEOSCIENCE, INC.

Robert l. Garfield

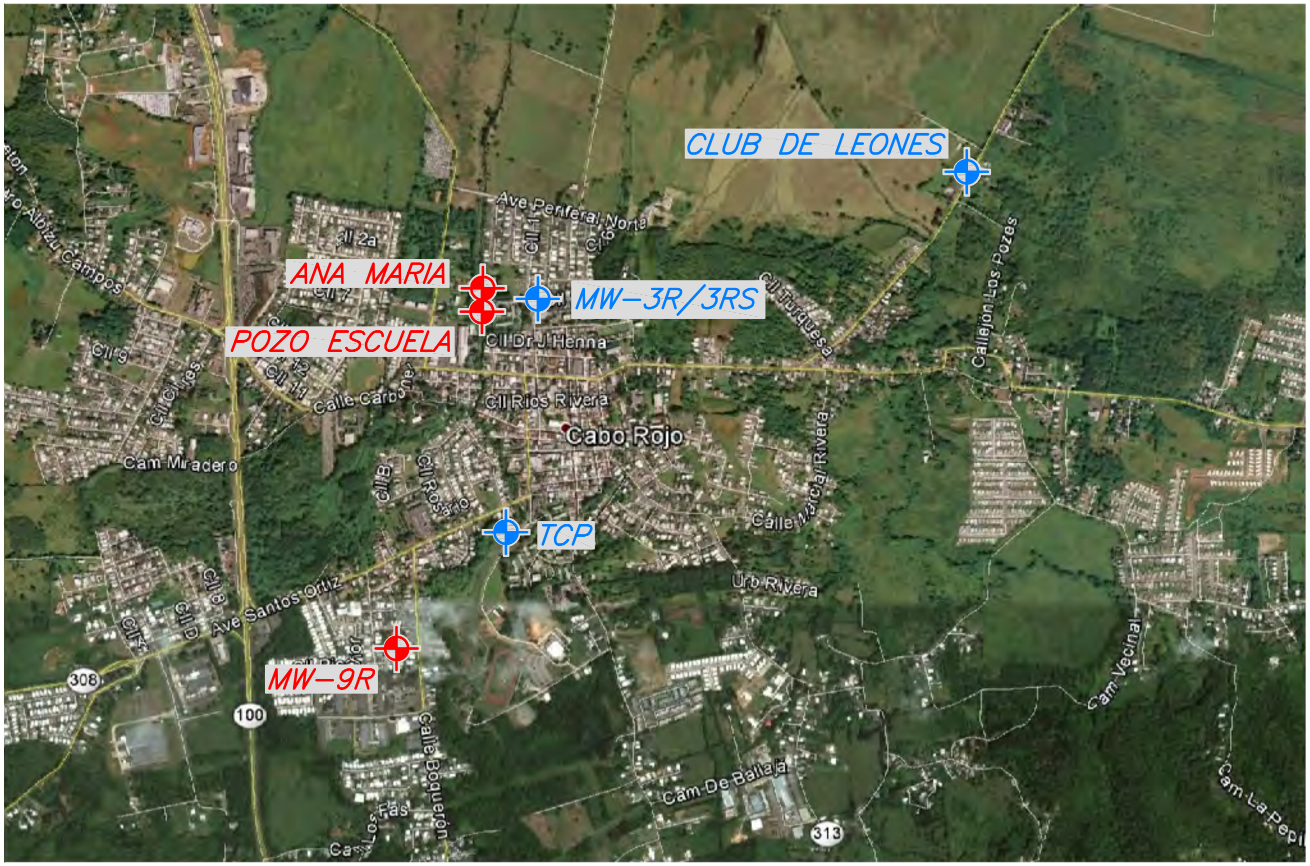
Robert Garfield	Dorothy Richter, P.G.
Vice President/Senior Borehole Geophysicist	President

List of Enclosures

Figures: Figure 1. Borehole Location Plan
Figure 2. Key to Bedrock Structure Categories
Figure 3. Tadpole Plot Explanation
Figure 4. Televiewer Explanation

Appendix 1: Borehole Geophysical Logs
Appendix 2: Bedrock Structure Statistics Plots
Appendix 3: Tables of Bedrock Structures

FIGURES



N

H-R

LEGEND

BOREHOLE LOGGED AND SAMPLED BY HAGER–RICHTER

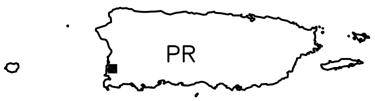
BOREHOLE SAMPLED BY HAGER–RICHTER

APPROXIMATE SCALE (feet)

0 1000 2000

NOTES:

1. Modified from Google Earth Pro aerial photograph.
2. Borehole approximate locations provided by CDM Smith.



LOCATION

Figure 1
Borehole Locations
Cabo Rojo Groundwater Contamination Site
Cabo Rojo, Puerto Rico

File 13RG03	November, 2013

HAGER–RICHTER GEOSCIENCE, INC.
Fords, New Jersey

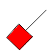
Tadpole	Structure Category (Symbol Color)	Description
	Fracture Rank 1 (Light Blue)	Minor Fracture - not distinct and may not be continuous around the borehole
	Fracture Rank 2 (Blue)	Intermediate Fracture - distinct and continuous around the borehole with little or no apparent aperture
	Fracture Rank 3 (Red)	Major Fracture - distinct and continuous around the borehole with apparent aperture

Figure 2. Key to bedrock structure categories.

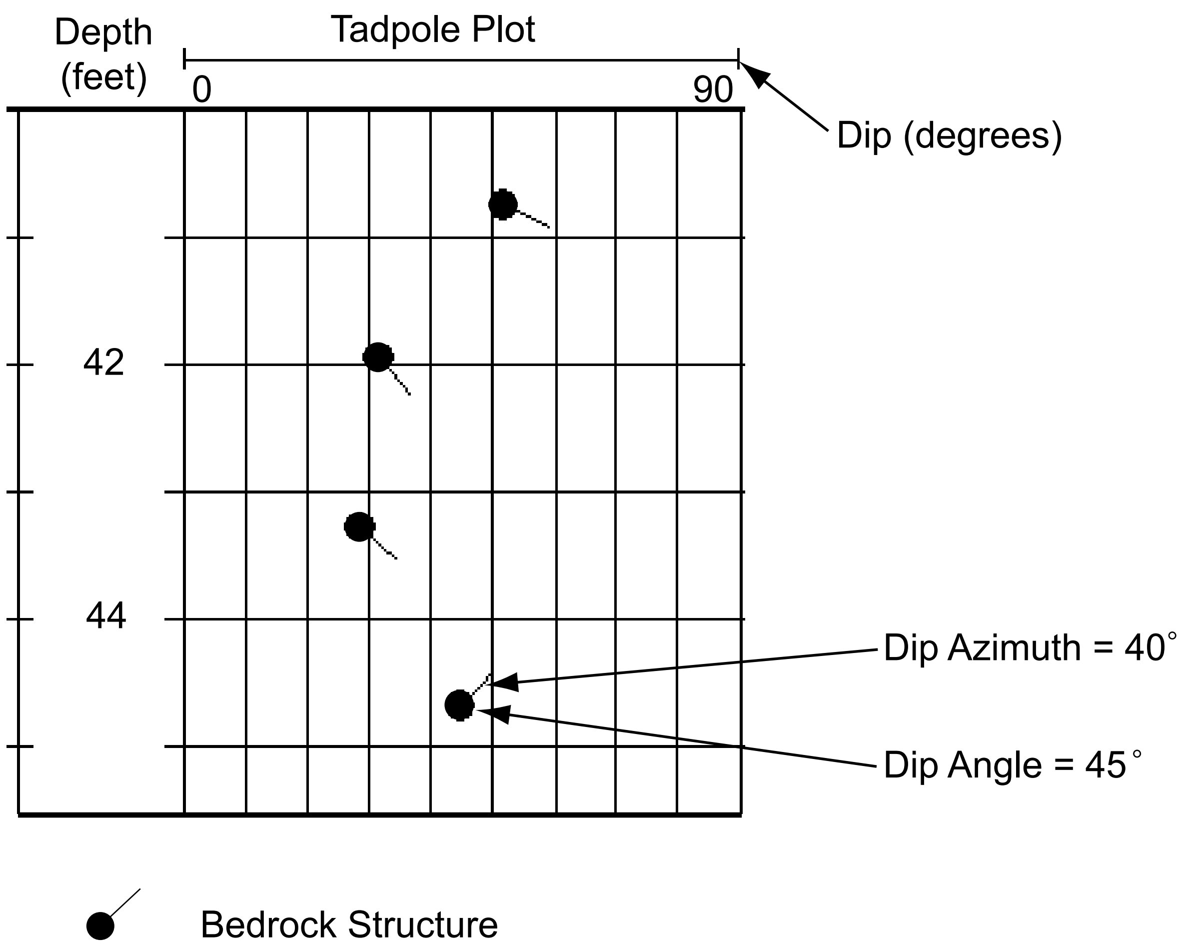


Figure 3. Tadpole plot explanation. The orientation of the bedrock structures is graphically displayed by a tadpole consisting of a circle, the head, and a line, the tail. The position of the head, left to right on the tadpole plot, gives the dip angle of the structure. The left side of the track indicates a dip angle of 0°, and the right side of the track indicates a dip angle of 90° from horizontal. The orientation of the tail gives the dip azimuth of the structure and can be read like a compass. The tail pointing directly up is 0°, north.

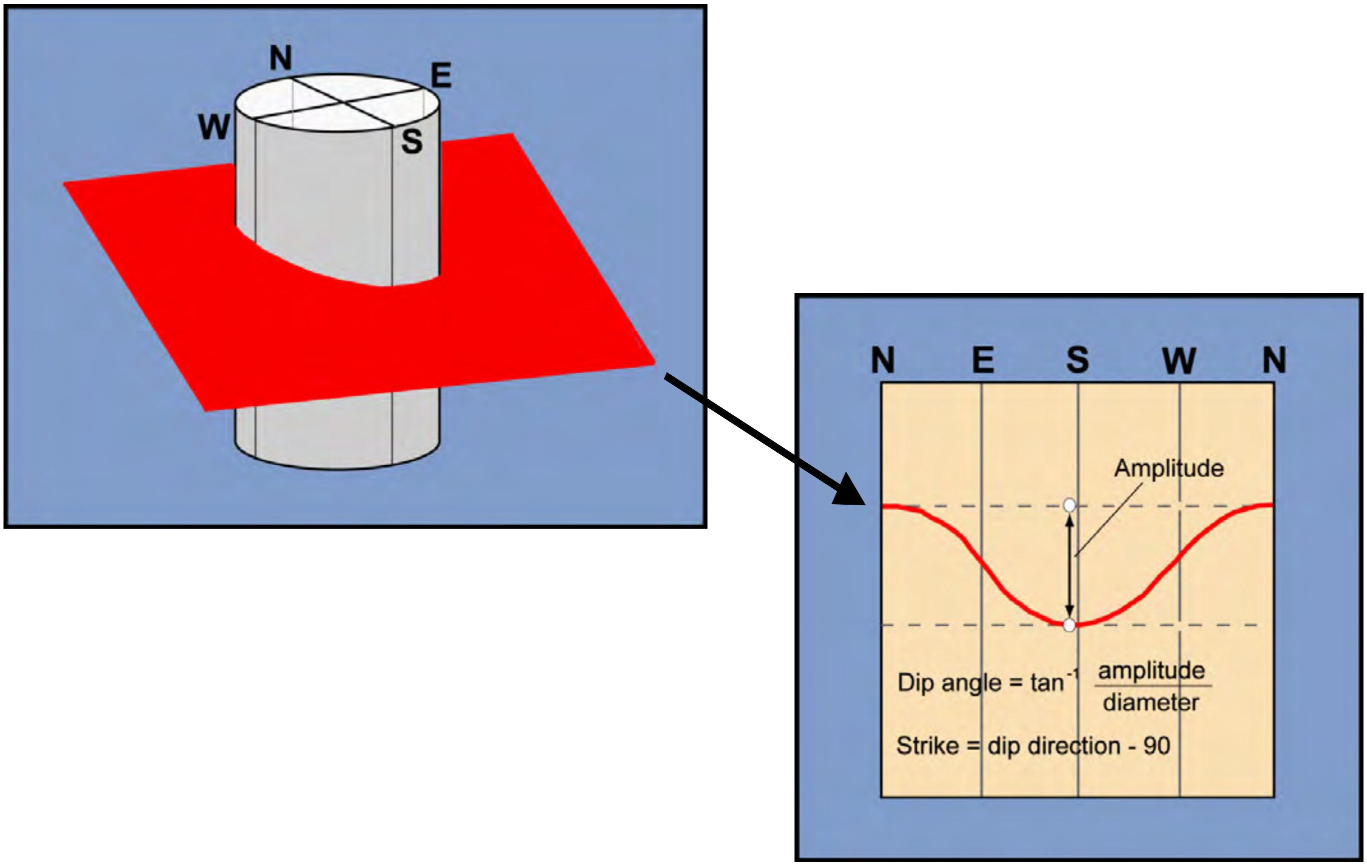


Figure 4. Televiewer explanation. The image on the left depicts a planar structure in red, such as a fracture or bedding plane, intersected by a borehole. The image on the right depicts the same structure unwrapped as it would be displayed in an optical televiewer (OTV) or acoustic televiewer (ATV) log.

Figure modified from: Garfield, R.L., Day-Lewis, F.D., Gray, M.B., Johnson, C.D., Williams, J.H. and Day-Lewis, A.D.F., 2003, Fractured-Rock Aquifer Characterization within a Regional Geologic Context: Results from the Bucknell University Hydrogeophysics Test Site, GSA Northeastern Section, 38th Annual Meeting, Paper No. 25-19.

APPENDIX 1

BOREHOLE GEOPHYSICAL LOGS

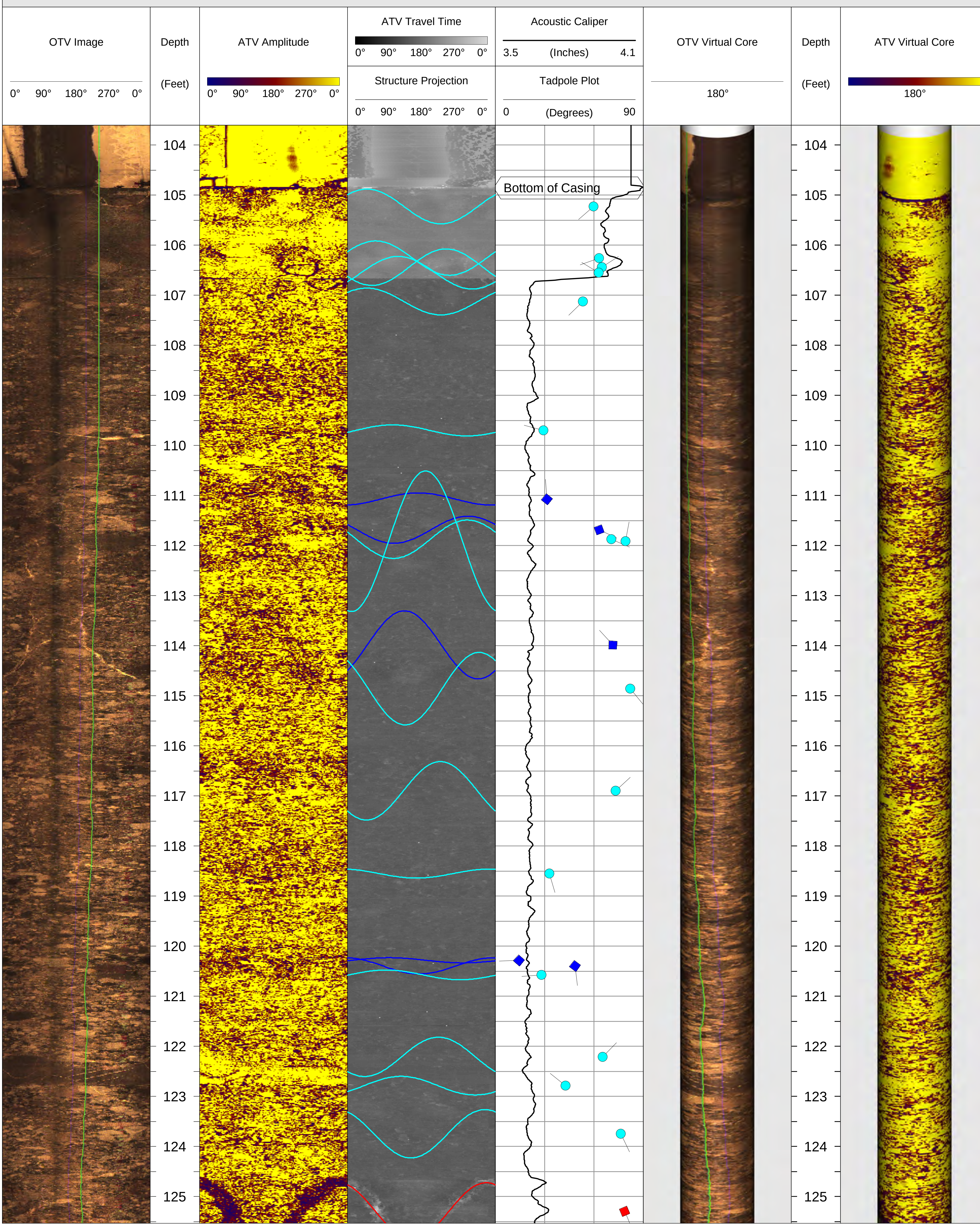
HAGER-RICHTER GEOSCIENCE, INC.	846 Main Street Fords, NJ 08863 Phone: 732-661-0555 Fax: 732-661-0123	MW-9R - BOREHOLE IMAGE LOGS DATE LOGGED:	 August 19, 2013

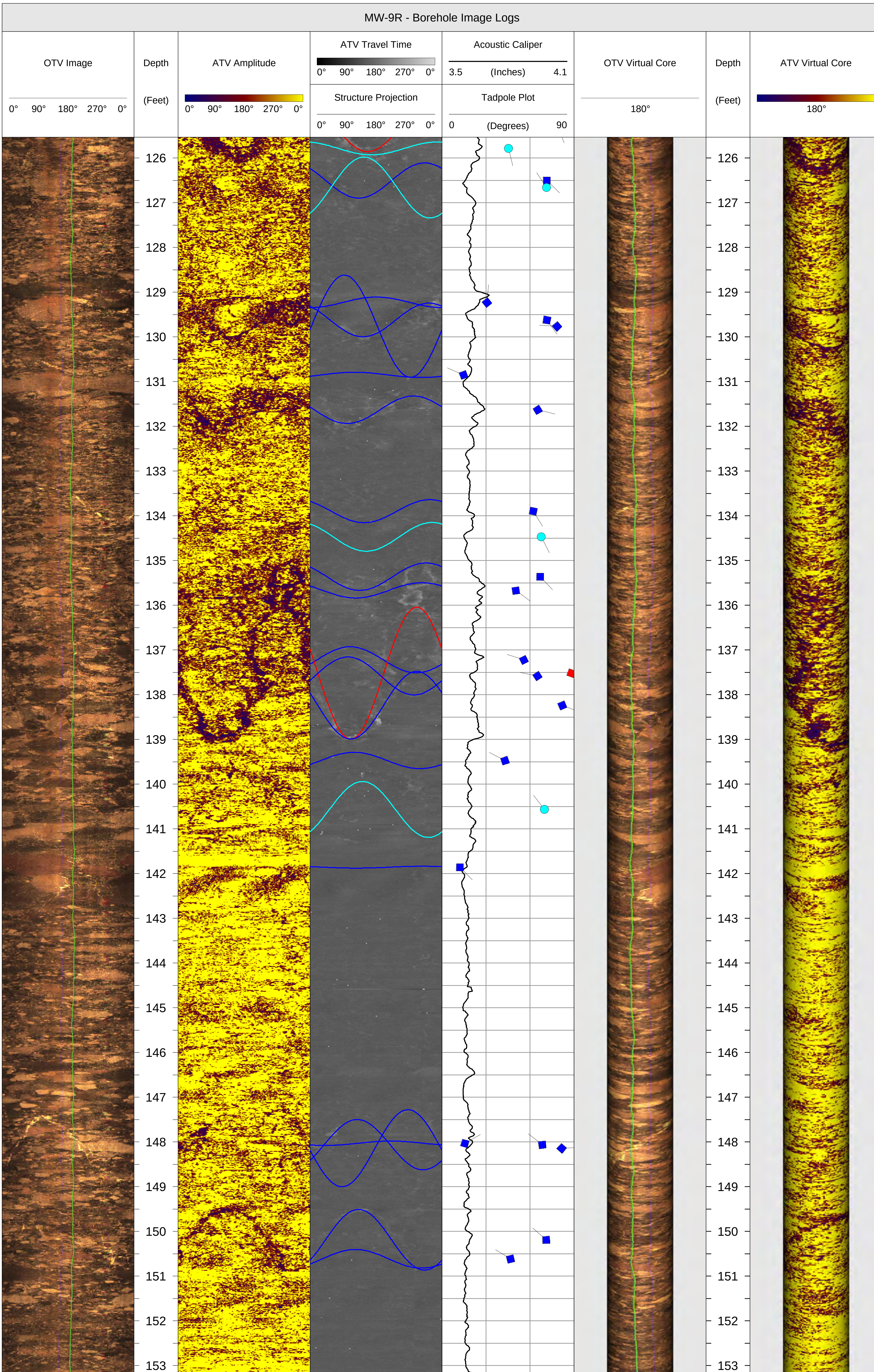
CLIENT:	CDM Smith	H-R FILE:	13RG03
PROJECT:	Cabo Rojo Groundwater Contamination Site	LOG DATUM:	Ground Surface (top of the concrete pad)
LOCATION:	Cabo Rojo, Puerto Rico	ORIENTATION REFERENCE:	True North (Magnetic Declination = 12° West)
LOGGING GEOPHYSICIST(S):	Robert Garfield & Nick DeCristofaro	TOP OF CASING:	2.7 Feet Above the Ground Surface
CLIENT REP. ON-SITE:	Jose Reyes	BOREHOLE DIAMETER:	4-Inch Open Bedrock
LOGS PROCESSED BY:	Robert Garfield	WATER LEVEL DEPTH:	16.0 Feet

STRUCTURE LEGEND

Fracture Rank 1 Fracture Rank 2 Fracture Rank 3

MW-9R - Borehole Image Logs




MW-9R - Borehole Image Logs
OTV Image
0° 90° 180° 270° 0°
Depth
(Feet)
ATV Amplitude
0° 90° 180° 270° 0°
ATV Travel Time
0° 90° 180° 270° 0°
Structure Projection
0° 90° 180° 270° 0°
Acoustic Caliper
3.5 (Inches) 4.1
Tadpole Plot
0 (Degrees) 90
OTV Virtual Core
180°
Depth
(Feet)
ATV Virtual Core
180°
126
127
128
129
130
131
132
133
134
135
136
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139
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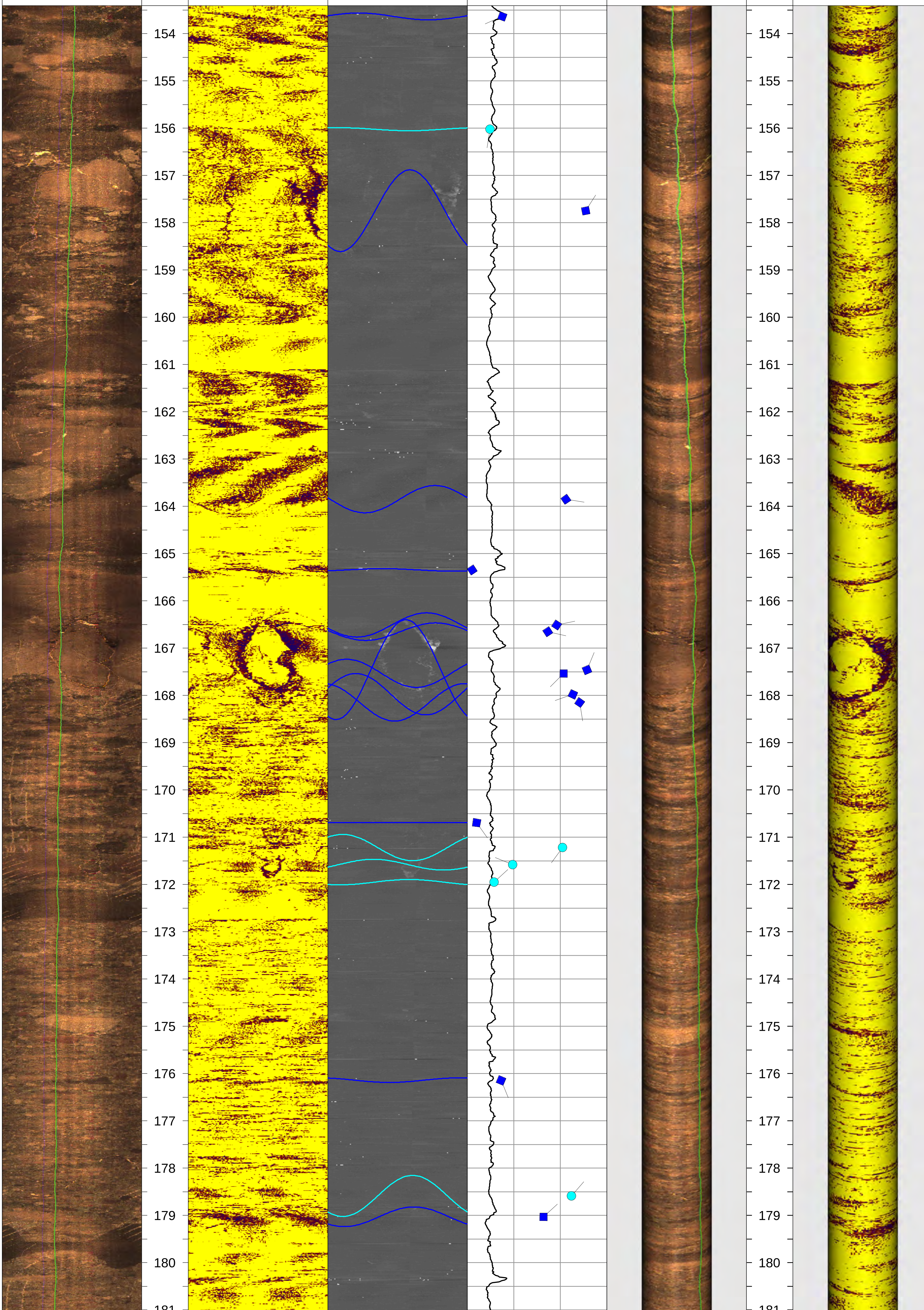
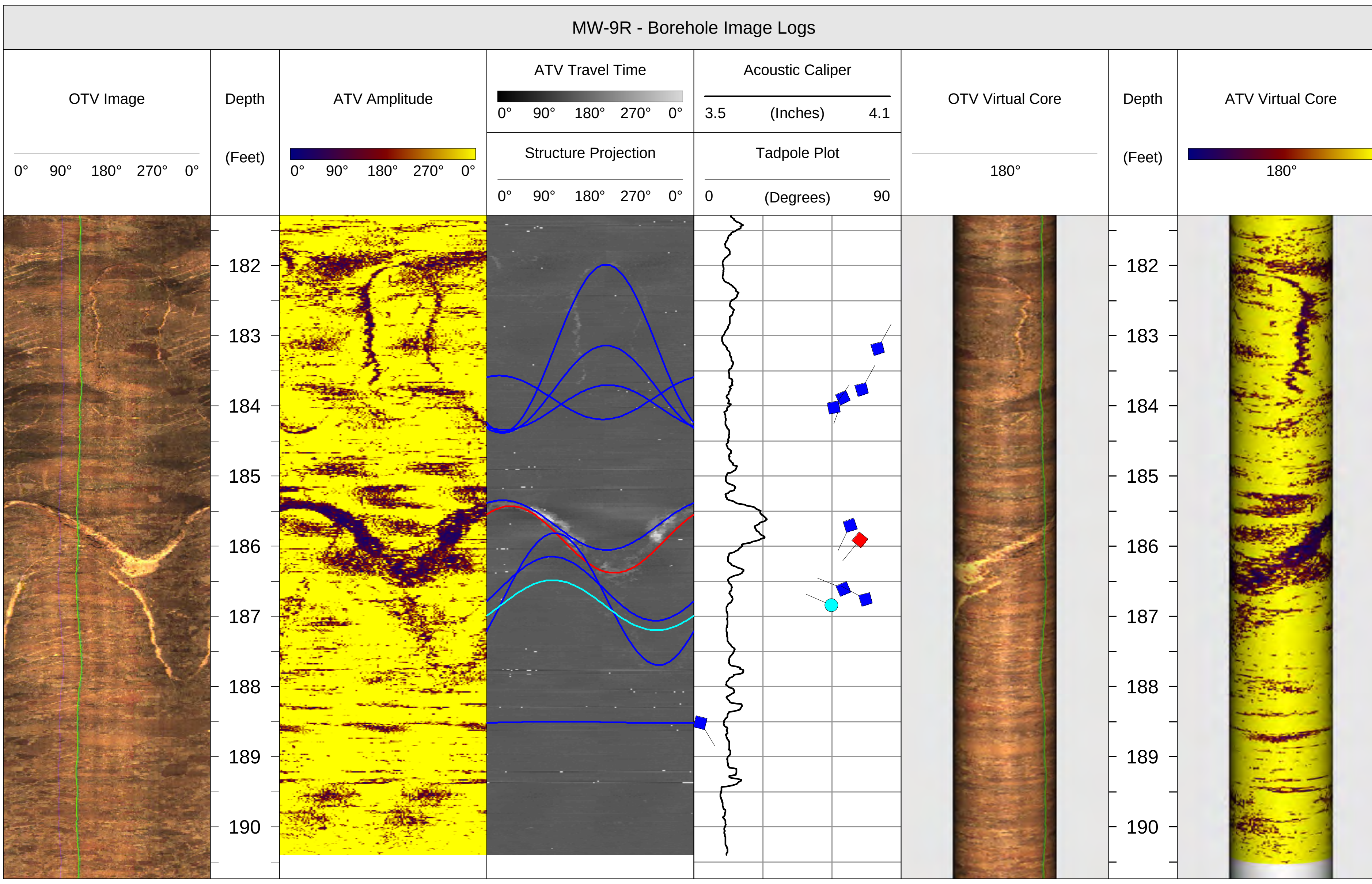
152
153

MW-9R - Borehole Image Logs

OTV Image	Depth	ATV Amplitude	ATV Travel Time / Structure Projection	Acoustic Caliper / Tadpole Plot	OTV Virtual Core	Depth	ATV Virtual Core
0° 90° 180° 270° 0°	(Feet)	0° 90° 180° 270° 0°	ATV Travel Time: 0° 90° 180° 270° 0°	Acoustic Caliper: 3.5 (Inches) 4.1	180°	(Feet)	180°
			Structure Projection: 0° 90° 180° 270° 0°	Tadpole Plot: 0 (Degrees) 90			




MW-9R - Borehole Image Logs
OTV Image
0° 90° 180° 270° 0°
Depth
(Feet)
ATV Amplitude
0° 90° 180° 270° 0°
ATV Travel Time
0° 90° 180° 270° 0°
Structure Projection
0° 90° 180° 270° 0°
Acoustic Caliper
3.5 (Inches) 4.1
Tadpole Plot
0 (Degrees) 90
OTV Virtual Core
180°
Depth
(Feet)
ATV Virtual Core
180°
182
183
184
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190

HAGER-RICHTER GEOSCIENCE, INC.	846 Main Street Fords, NJ 08863 Phone: 732-661-0555 Fax: 732-661-0123	MW-9R - BOREHOLE GEOPHYSICAL LOGS DATE LOGGED: August 19, 2013

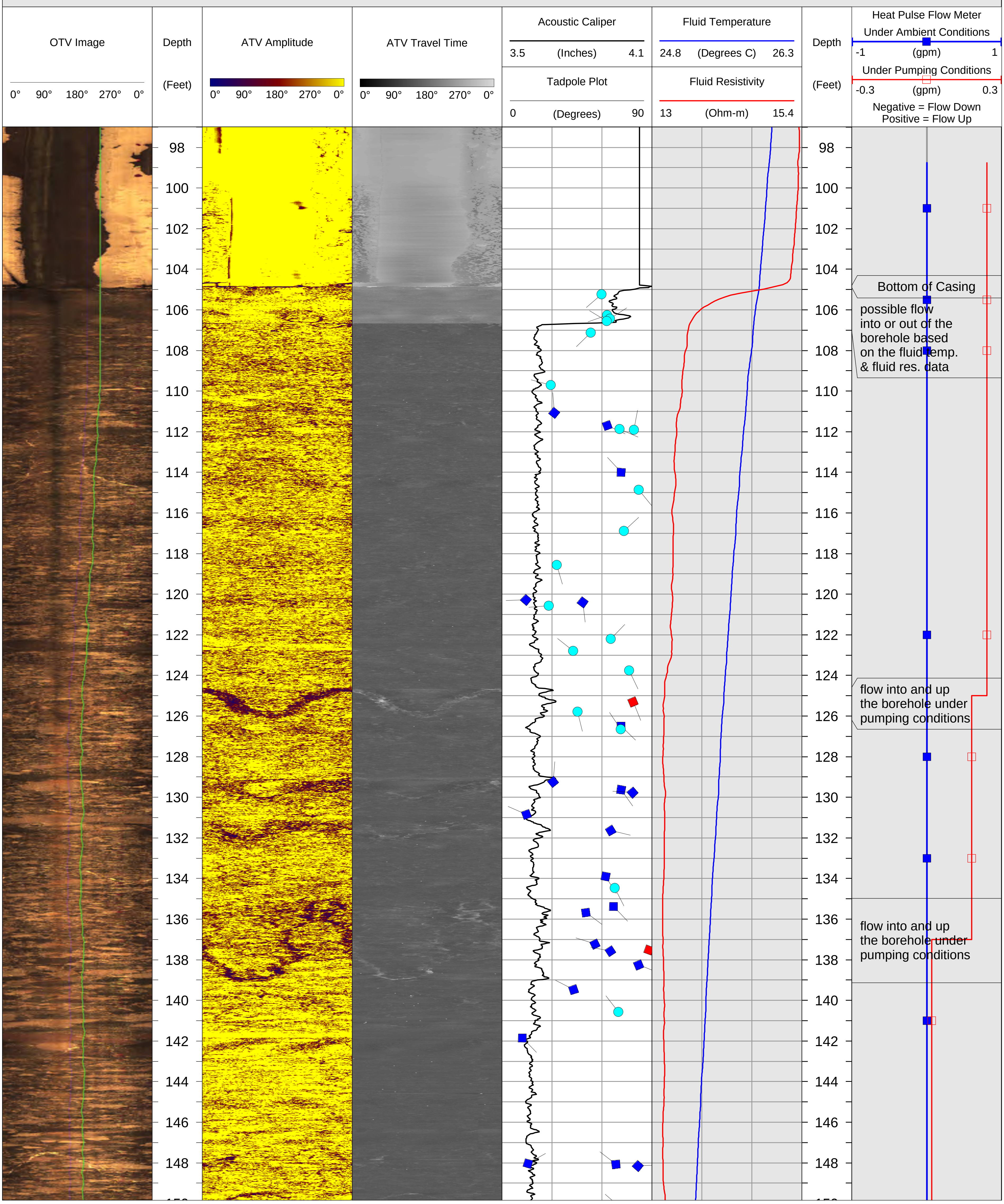
CLIENT:	CDM Smith	H-R FILE:	13RG03
PROJECT:	Cabo Rojo Groundwater Contamination Site	LOG DATUM:	Ground Surface (top of the concrete pad)
LOCATION:	Cabo Rojo, Puerto Rico	ORIENTATION REFERENCE:	True North (Magnetic Declination = 12° West)
LOGGING GEOPHYSICIST(S):	Robert Garfield & Nick DeCristofaro	TOP OF CASING:	2.7 Feet Above the Ground Surface
CLIENT REP. ON-SITE:	Jose Reyes	BOREHOLE DIAMETER:	4-Inch Open Bedrock
LOGS PROCESSED BY:	Robert Garfield	WATER LEVEL DEPTH:	16.0 Feet

STRUCTURE LEGEND

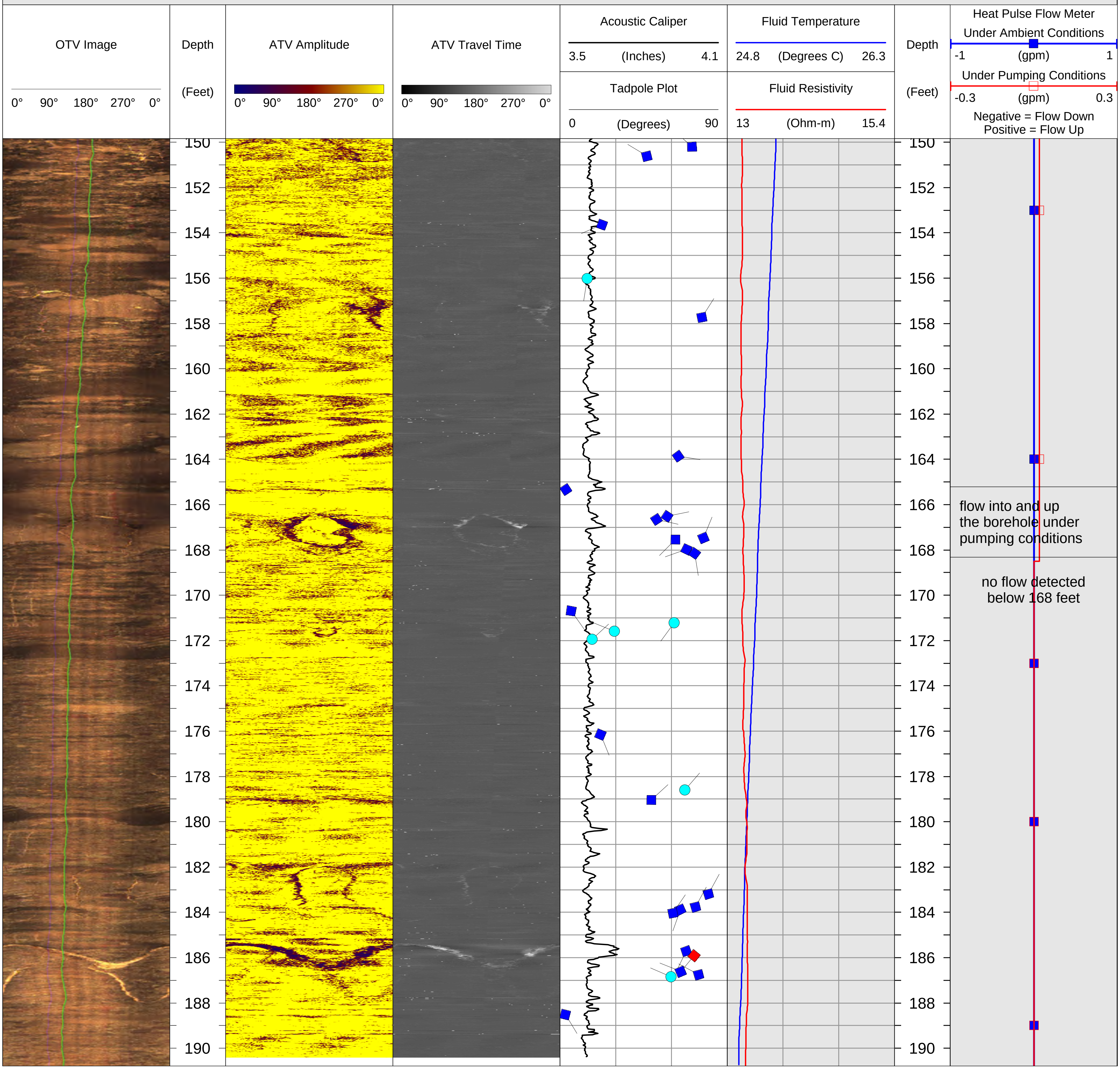
Fracture Rank 1 Fracture Rank 2 Fracture Rank 3

NOTES: Flow was not detected in MW-9R with the heat pulse flow meter under ambient conditions.

MW-9R - Borehole Geophysical Logs



MW-9R - Borehole Geophysical Logs



HAGER-RICHTER GEOSCIENCE, INC.

846 Main Street
Fords, NJ 08863
Phone: 732-661-0555
Fax: 732-661-0123

ANA MARIA - BOREHOLE IMAGE LOGS

DATE LOGGED: August 21, 2013

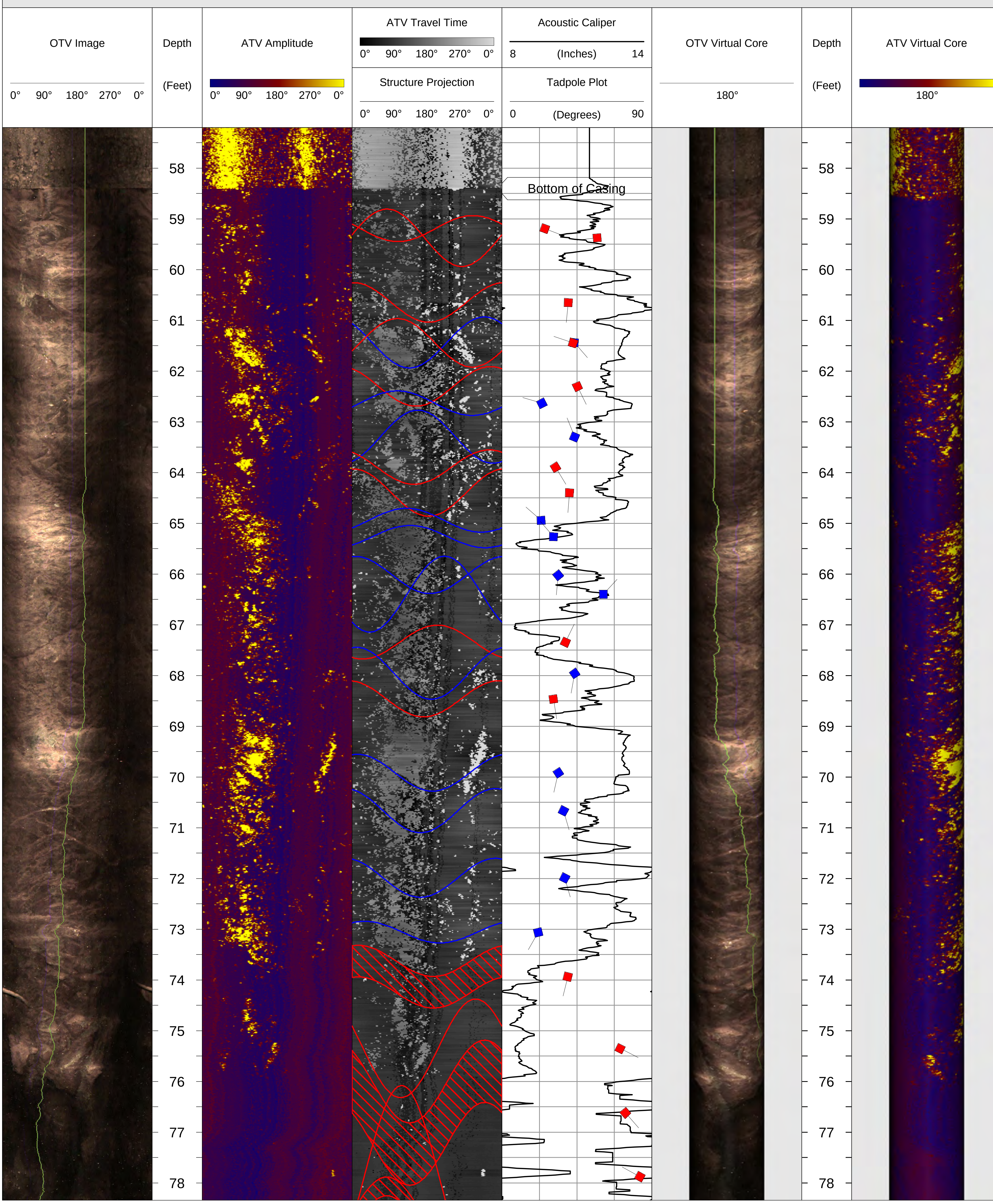
CLIENT:	CDM Smith	H-R FILE:	13RG03
PROJECT:	Cabo Rojo Groundwater Contamination Site	LOG DATUM:	Ground Surface (top of the concrete pad)
LOCATION:	Cabo Rojo, Puerto Rico	ORIENTATION REFERENCE:	True North (Magnetic Declination = 12° West)
LOGGING GEOPHYSICIST(S):	Robert Garfield & Nick DeCristofaro	TOP OF CASING:	2.2 Feet Above the Ground Surface
CLIENT REP. ON-SITE:	Jose Reyes	BOREHOLE DIAMETER:	10-Inch Open Bedrock
LOGS PROCESSED BY:	Robert Garfield	WATER LEVEL DEPTH:	12.6 Feet

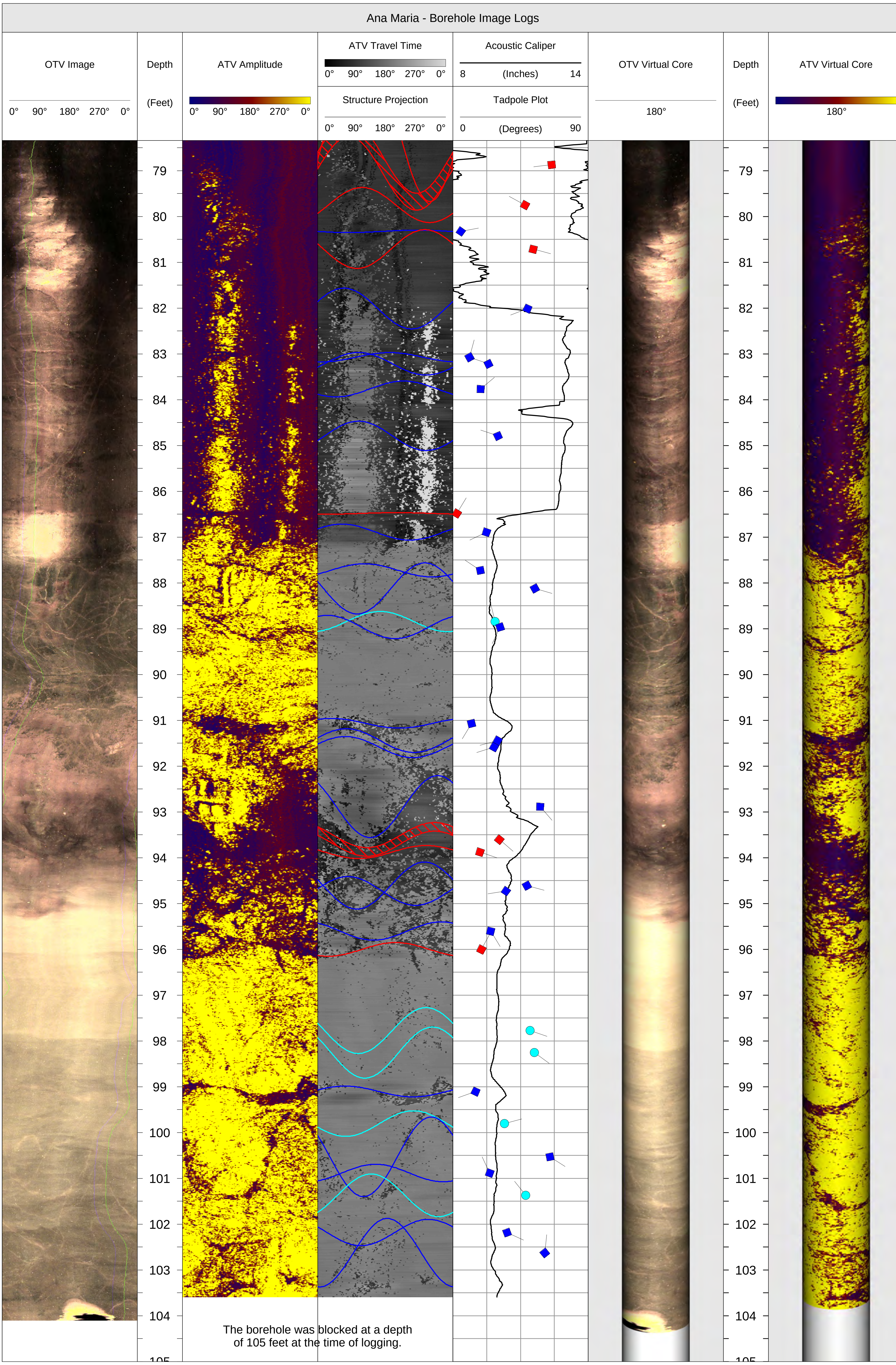
STRUCTURE LEGEND

Fracture Rank 1   Fracture Rank 2   Fracture Rank 3

NOTES: The borehole was blocked at a depth of 105 feet at the time of logging.

Ana Maria - Borehole Image Logs




Ana Maria - Borehole Image Logs
OTV Image
0° 90° 180° 270° 0°
Depth
(Feet)
ATV Amplitude
0° 90° 180° 270° 0°
ATV Travel Time
0° 90° 180° 270° 0°
Structure Projection
0° 90° 180° 270° 0°
Acoustic Caliper
8 (Inches) 14
Tadpole Plot
0 (Degrees) 90
OTV Virtual Core
180°
ATV Virtual Core
180°
79
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The borehole was blocked at a depth
of 105 feet at the time of logging.

HAGER-RICHTER GEOSCIENCE, INC.

846 Main Street
Fords, NJ 08863
Phone: 732-661-0555
Fax: 732-661-0123

ANA MARIA - BOREHOLE GEOPHYSICAL LOGS

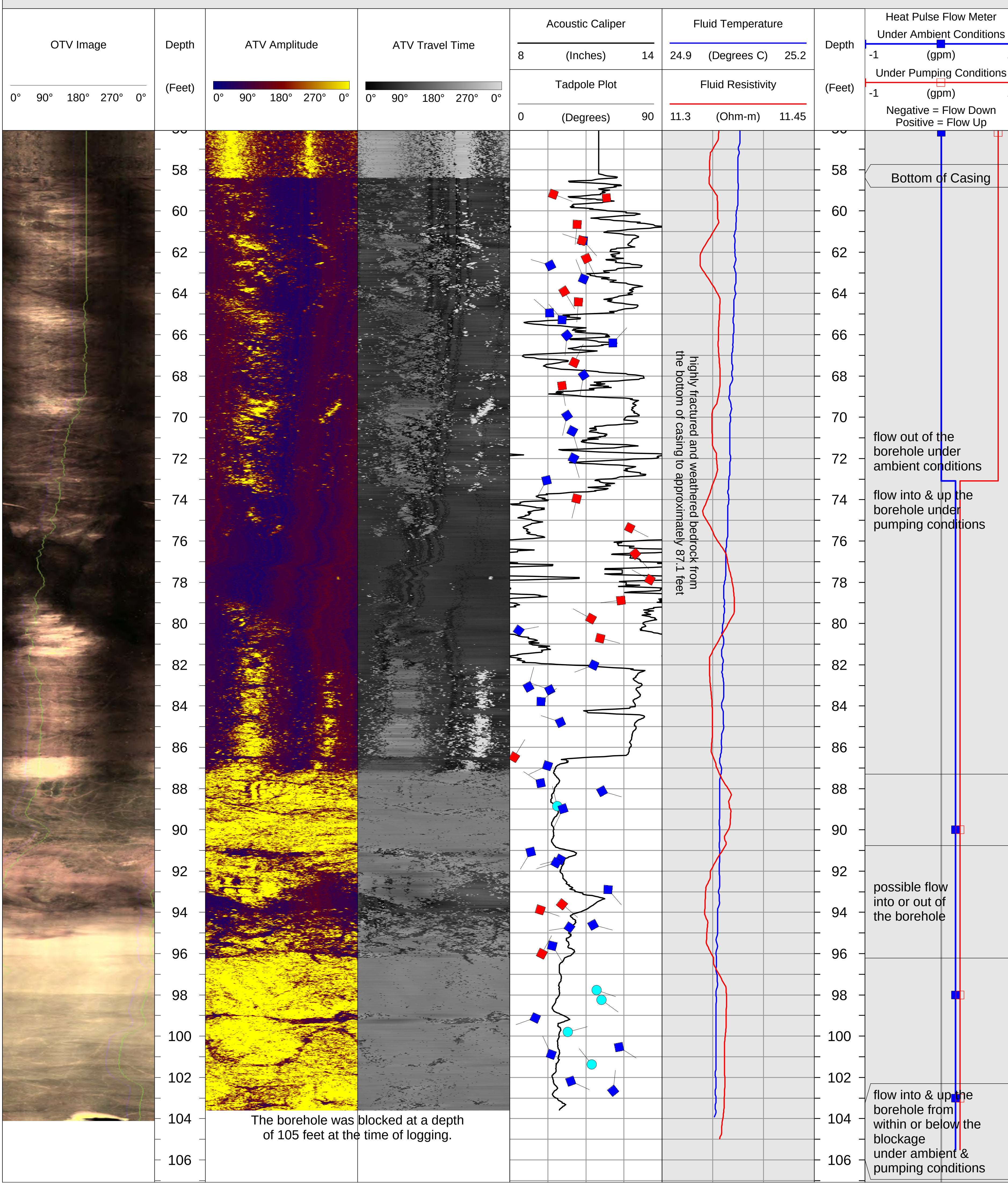
DATE LOGGED:	August 21, 2013		
CLIENT:	CDM Smith	H-R FILE:	13RG03
PROJECT:	Cabo Rojo Groundwater Contamination Site	LOG DATUM:	Ground Surface (top of the concrete pad)
LOCATION:	Cabo Rojo, Puerto Rico	ORIENTATION REFERENCE:	True North (Magnetic Declination = 12° West)
LOGGING GEOPHYSICIST(S):	Robert Garfield & Nick DeCristofaro	TOP OF CASING:	2.2 Feet Above the Ground Surface
CLIENT REP. ON-SITE:	Jose Reyes	BOREHOLE DIAMETER:	10-Inch Open Bedrock
LOGS PROCESSED BY:	Robert Garfield	WATER LEVEL DEPTH:	12.6 Feet

STRUCTURE LEGEND

Fracture Rank 1 · Fracture Rank 2 · Fracture Rank 3

NOTES: The borehole was blocked at a depth of 105 feet at the time of logging.

Ana Maria - Borehole Geophysical Logs



HAGER-RICHTER GEOSCIENCE, INC.

846 Main Street
Fords, NJ 08863
Phone: 732-661-0555
Fax: 732-661-0123

POZO ESCUELA - BOREHOLE IMAGE LOGS

DATE LOGGED: August 20, 2013

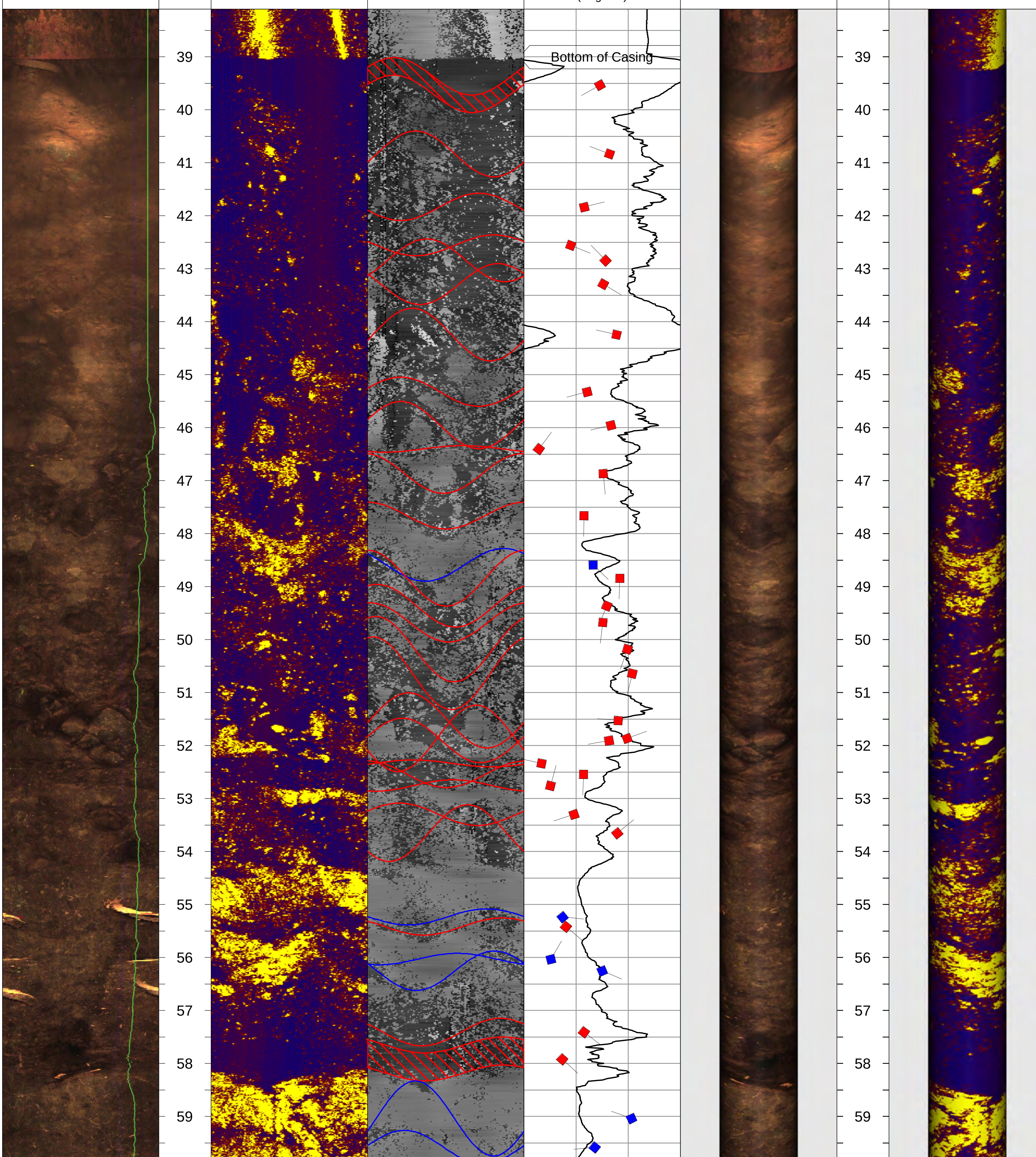
CLIENT:	CDM Smith	H-R FILE:	13RG03
PROJECT:	Cabo Rojo Groundwater Contamination Site	LOG DATUM:	Ground Surface (top of the concrete pad)
LOCATION:	Cabo Rojo, Puerto Rico	ORIENTATION REFERENCE:	True North (Magnetic Declination = 12° West)
LOGGING GEOPHYSICIST(S):	Robert Garfield & Nick DeCristofaro	TOP OF CASING:	0.7 Feet Above the Ground Surface
CLIENT REP. ON-SITE:	Frances Delano & Jose Reyes	BOREHOLE DIAMETER:	10-Inch Open Bedrock
LOGS PROCESSED BY:	Robert Garfield	WATER LEVEL DEPTH:	10.3 Feet

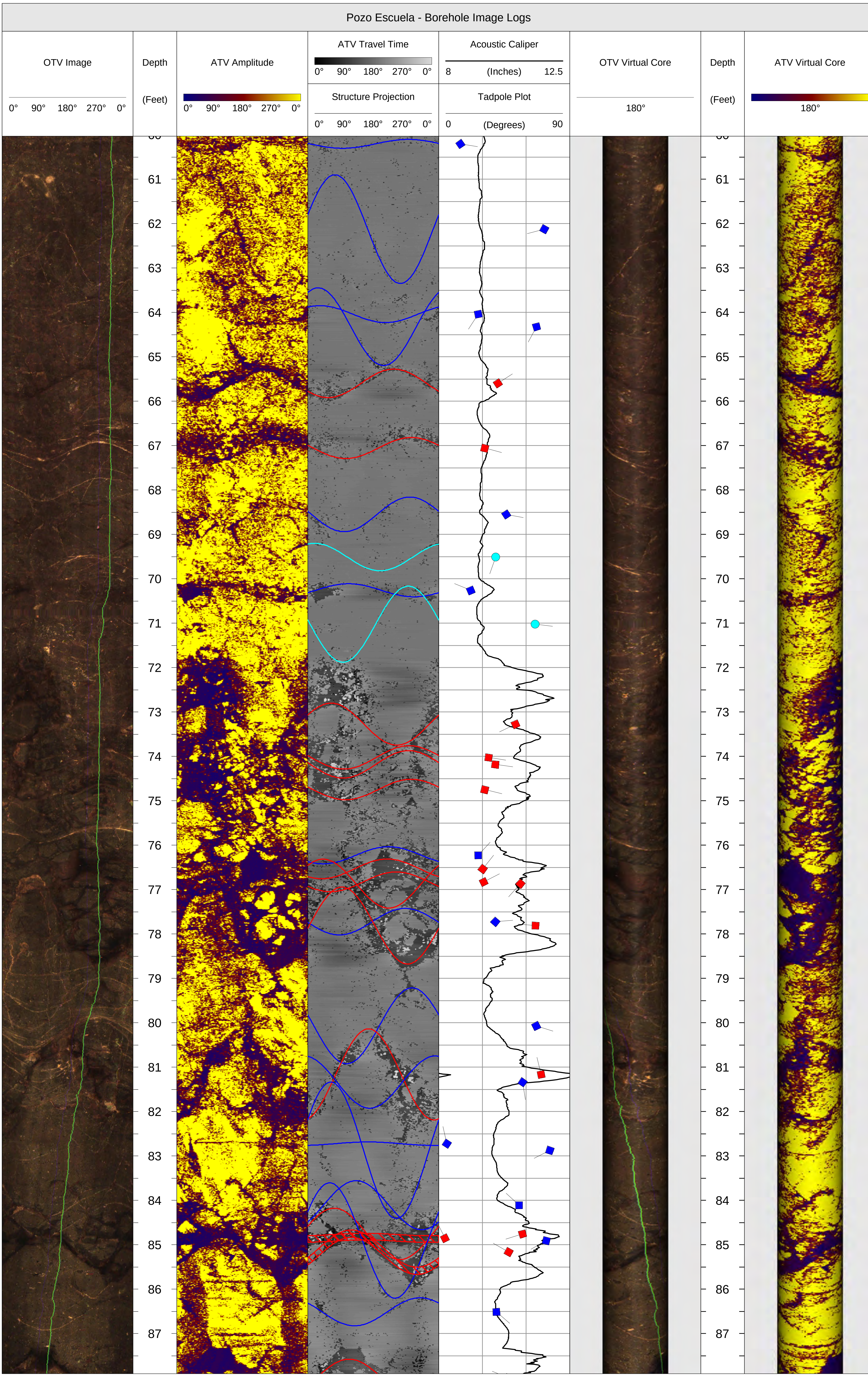
STRUCTURE LEGEND

Fracture Rank 1 Fracture Rank 2 Fracture Rank 3

Pozo Escuela - Borehole Image Logs

OTV Image	Depth (Feet)	ATV Amplitude	ATV Travel Time / Structure Projection	Acoustic Caliper / Tadpole Plot	OTV Virtual Core	Depth (Feet)	ATV Virtual Core
0° 90° 180° 270° 0°		0° 90° 180° 270° 0°	0° 90° 180° 270° 0° / 0° 90° 180° 270° 0°	8 (Inches) 12.5 / 0 (Degrees) 90	180°		180°




Pozo Escuela - Borehole Image Logs
OTV Image
0° 90° 180° 270° 0°
Depth
(Feet)
ATV Amplitude
0° 90° 180° 270° 0°
ATV Travel Time
0° 90° 180° 270° 0°
Structure Projection
0° 90° 180° 270° 0°
Acoustic Caliper
8 (Inches) 12.5
Tadpole Plot
0 (Degrees) 90
OTV Virtual Core
180°
Depth
(Feet)
ATV Virtual Core
180°
61
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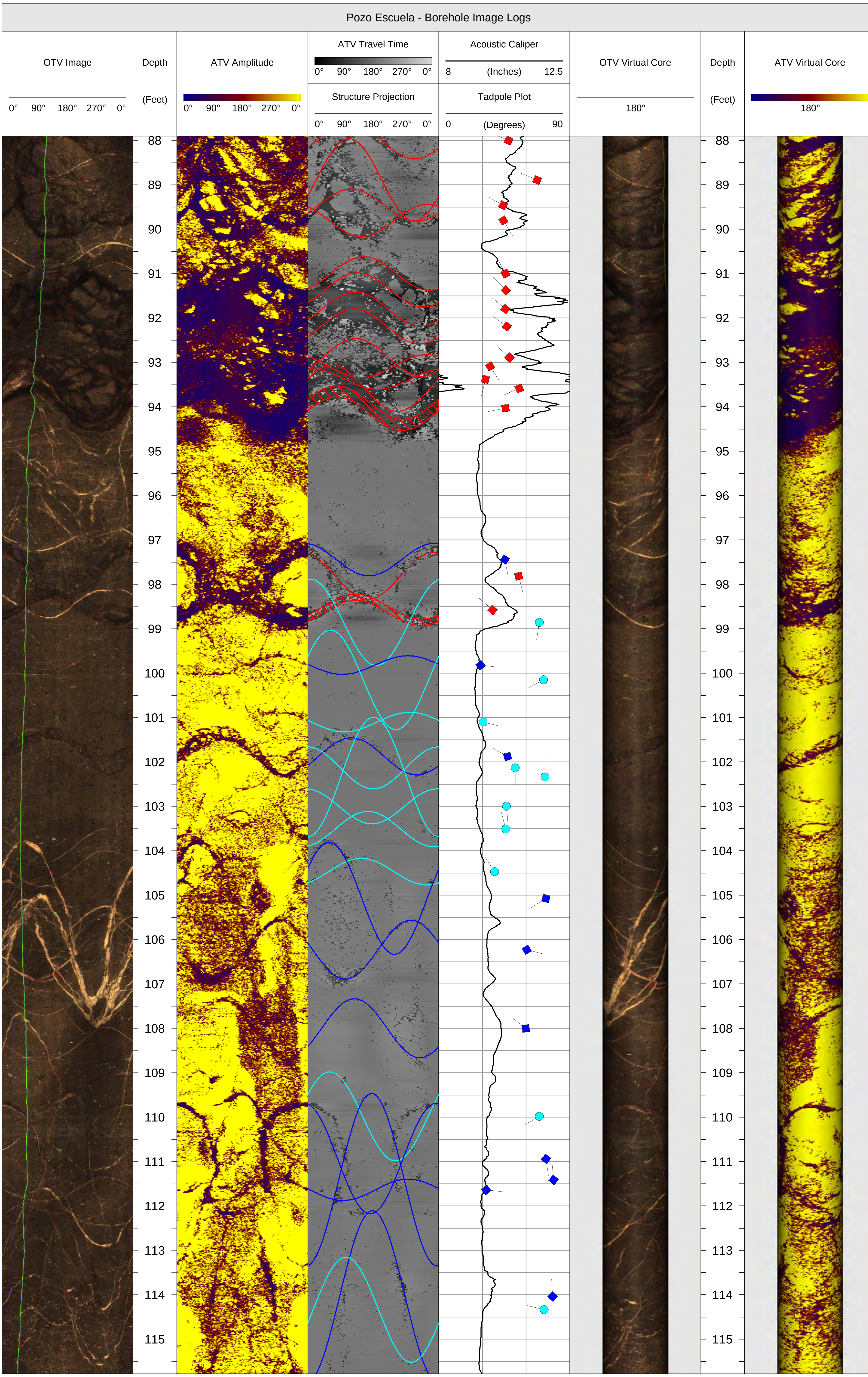
Pozo Escuela - Borehole Image Logs
OTV Image
0° 90° 180° 270° 0°
Depth
(Feet)
ATV Amplitude
0° 90° 180° 270° 0°
ATV Travel Time
0° 90° 180° 270° 0°
Structure Projection
0° 90° 180° 270° 0°
Acoustic Caliper
8 (Inches) 12.5
Tadpole Plot
0 (Degrees) 90
OTV Virtual Core
180°
Depth
(Feet)
ATV Virtual Core
180°
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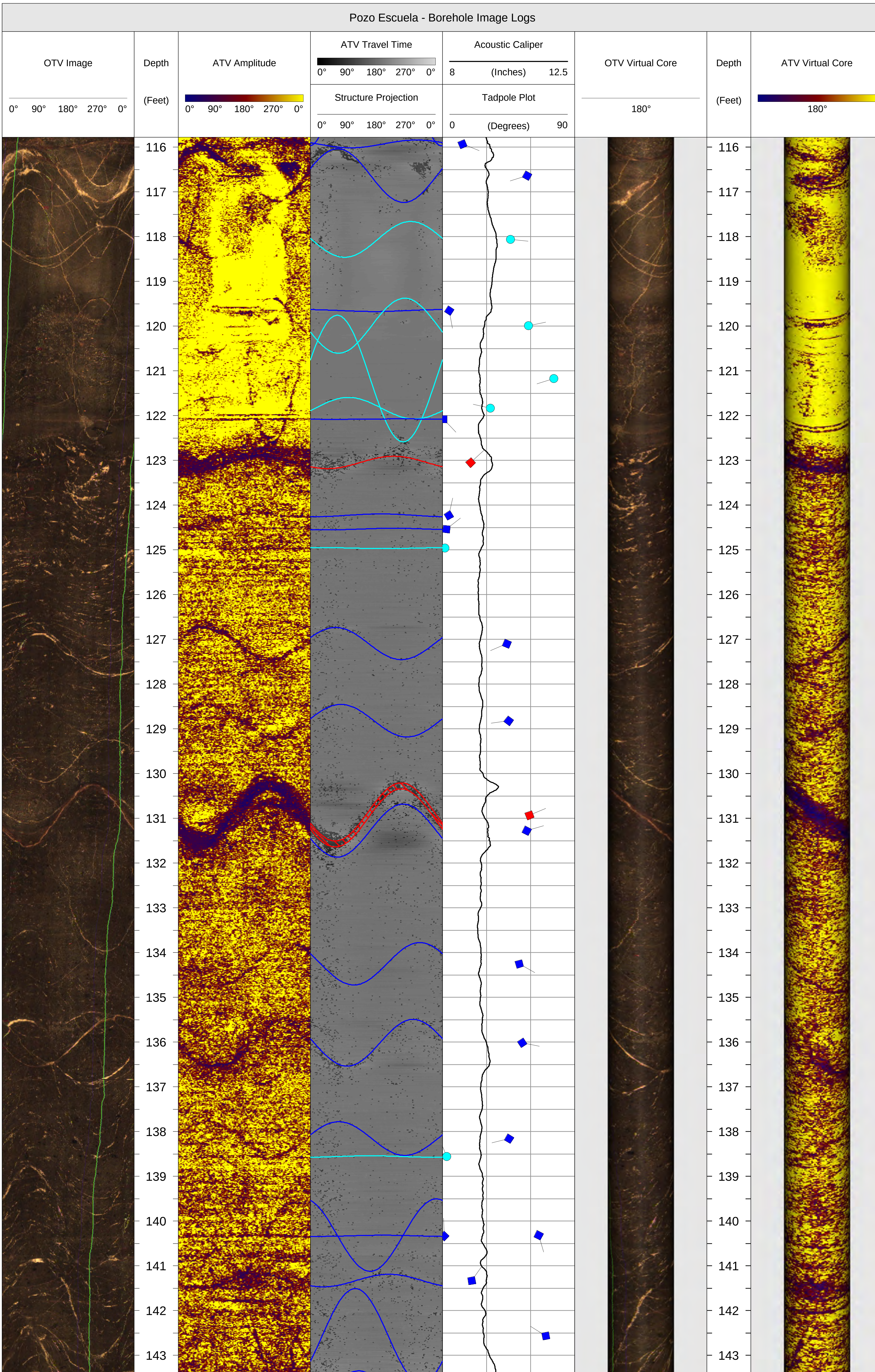

Pozo Escuela - Borehole Image Logs
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Depth
(Feet)
ATV Amplitude
0° 90° 180° 270° 0°
ATV Travel Time
0° 90° 180° 270° 0°
Structure Projection
0° 90° 180° 270° 0°
Acoustic Caliper
8 (Inches) 12.5
Tadpole Plot
0 (Degrees) 90
OTV Virtual Core
180°
Depth
(Feet)
ATV Virtual Core
180°
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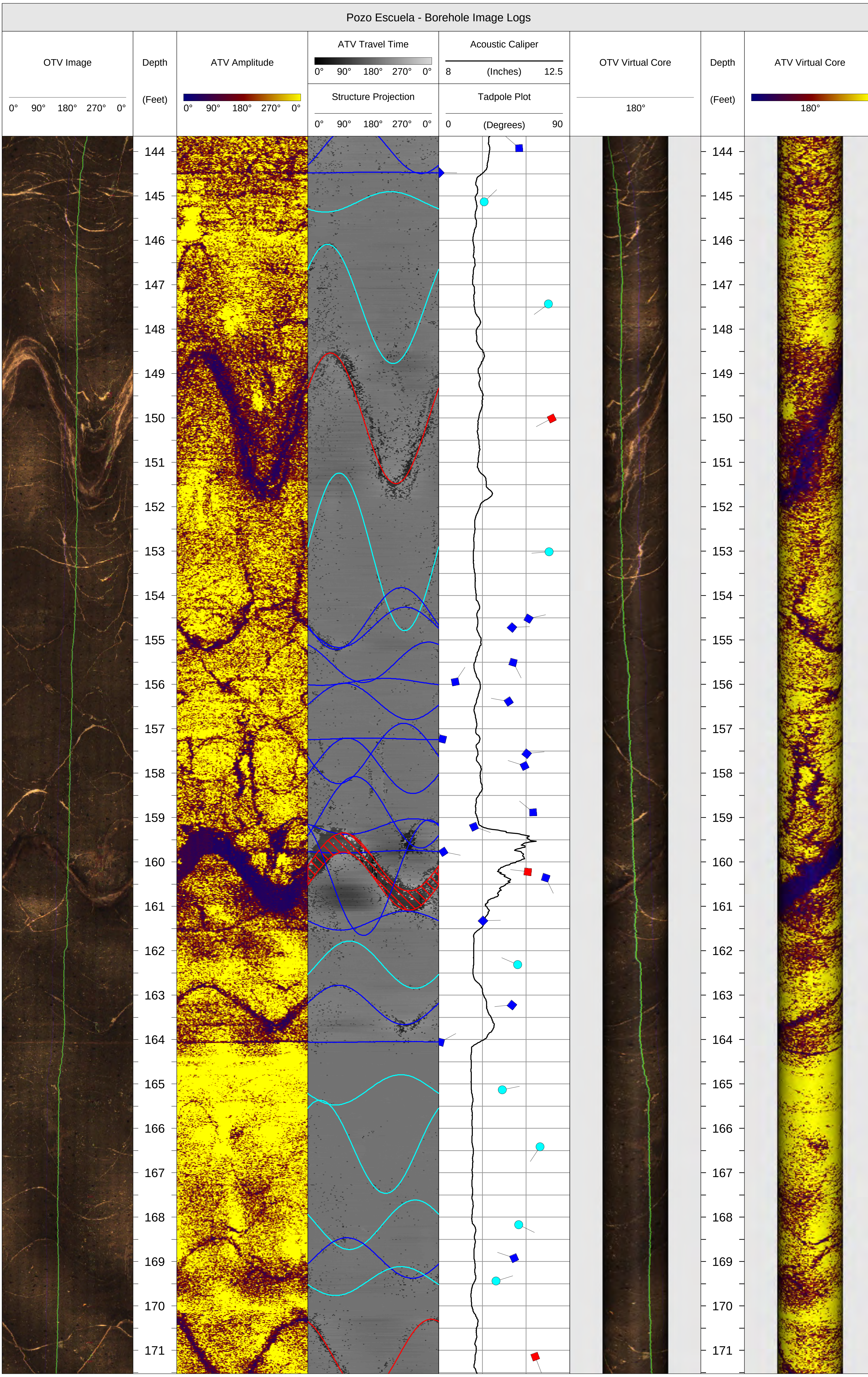
Pozo Escuela - Borehole Image Logs
OTV Image
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Depth
(Feet)
ATV Amplitude
0° 90° 180° 270° 0°
ATV Travel Time
0° 90° 180° 270° 0°
Structure Projection
0° 90° 180° 270° 0°
Acoustic Caliper
8 (Inches) 12.5
Tadpole Plot
0 (Degrees) 90
OTV Virtual Core
180°
Depth
(Feet)
ATV Virtual Core
180°
144
145
146
147
148
149
150
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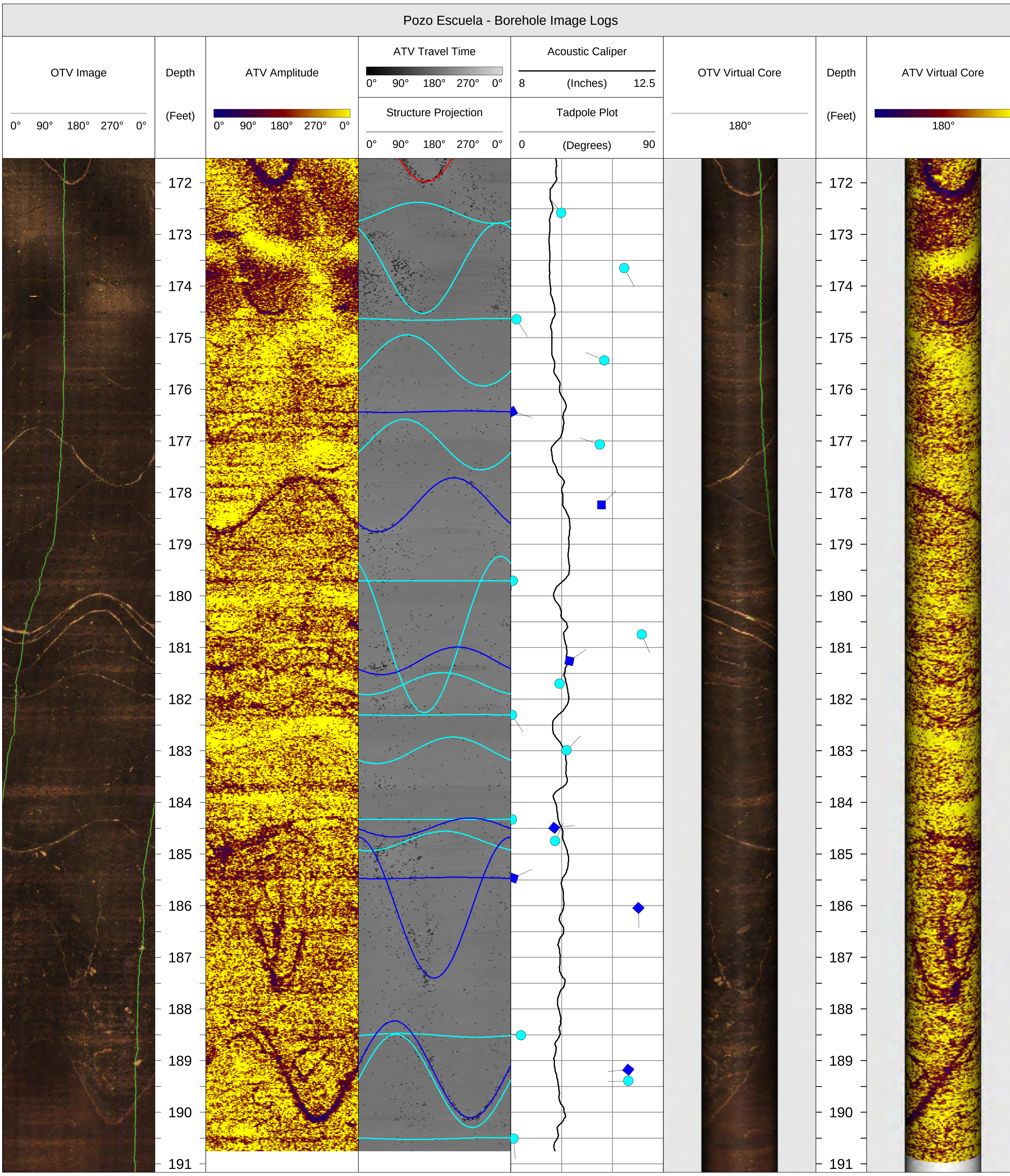

Pozo Escuela - Borehole Image Logs
OTV Image
0° 90° 180° 270° 0°
Depth
(Feet)
ATV Amplitude
0° 90° 180° 270° 0°
ATV Travel Time
0° 90° 180° 270° 0°
Structure Projection
0° 90° 180° 270° 0°
Acoustic Caliper
8 (Inches) 12.5
Tadpole Plot
0 (Degrees) 90
OTV Virtual Core
180°
Depth
(Feet)
ATV Virtual Core
180°
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191

HAGER-RICHTER GEOSCIENCE, INC.

846 Main Street
Fords, NJ 08863
Phone: 732-661-0555
Fax: 732-661-0123

POZO ESCUELA - BOREHOLE GEOPHYSICAL LOGS

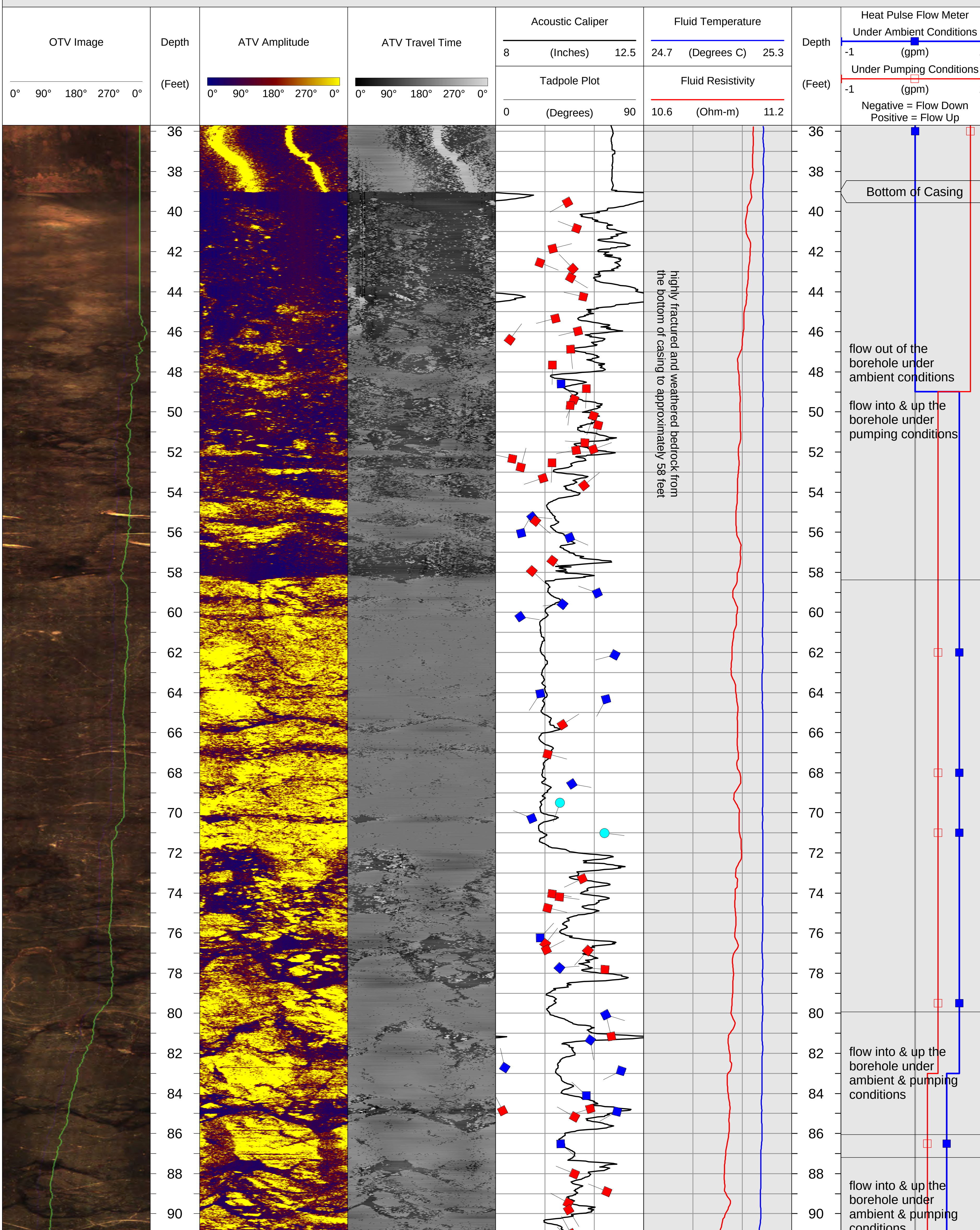
DATE LOGGED: August 20, 2013

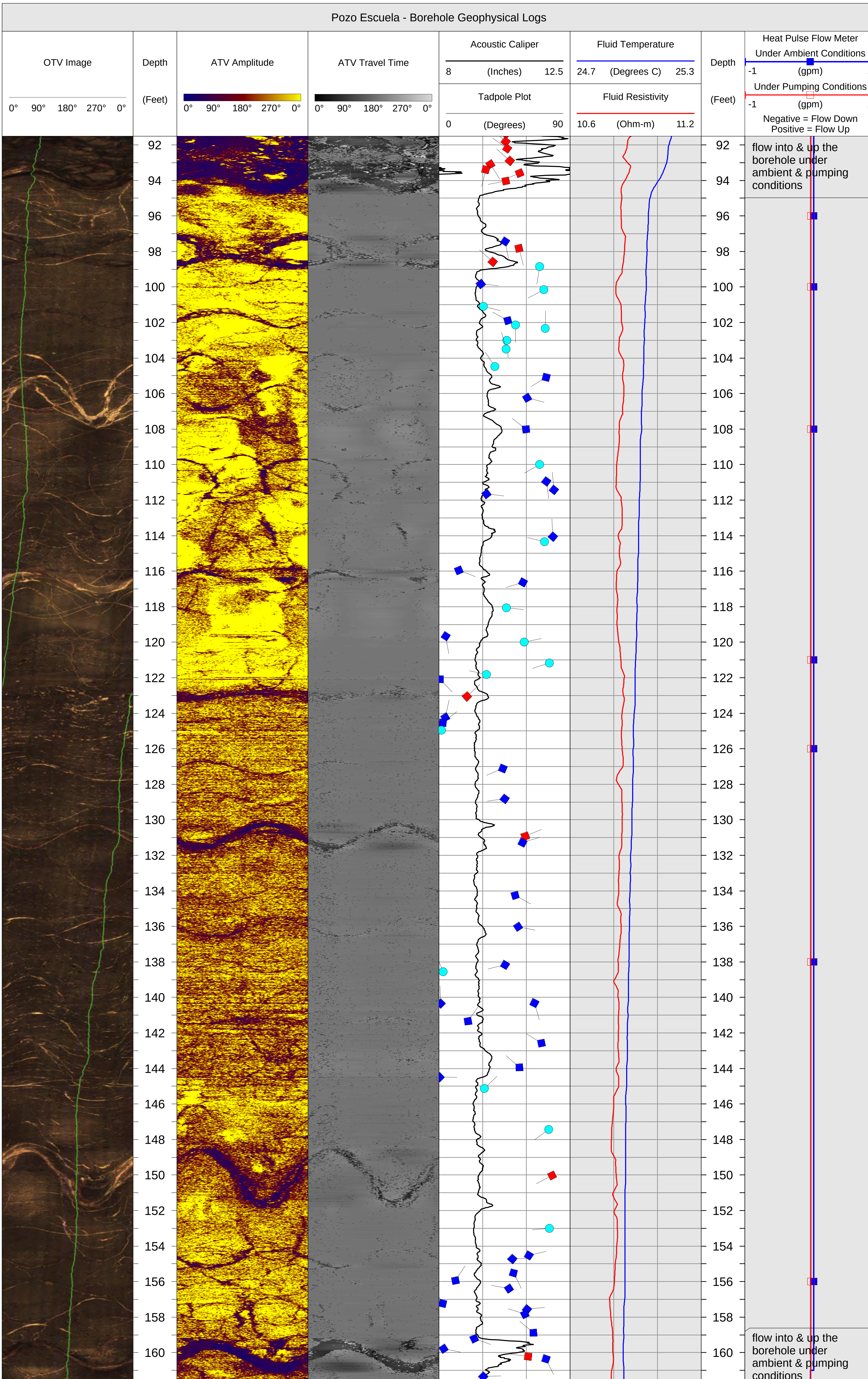
CLIENT:	CDM Smith	H-R FILE:	13RG03
PROJECT:	Cabo Rojo Groundwater Contamination Site	LOG DATUM:	Ground Surface (top of the concrete pad)
LOCATION:	Cabo Rojo, Puerto Rico	ORIENTATION REFERENCE:	True North (Magnetic Declination = 12° West)
LOGGING GEOPHYSICIST(S):	Robert Garfield & Nick DeCristofaro	TOP OF CASING:	0.7 Feet Above the Ground Surface
CLIENT REP. ON-SITE:	Frances Delano & Jose Reyes	BOREHOLE DIAMETER:	10-Inch Open Bedrock
LOGS PROCESSED BY:	Robert Garfield	WATER LEVEL DEPTH:	10.3 Feet

STRUCTURE LEGEND

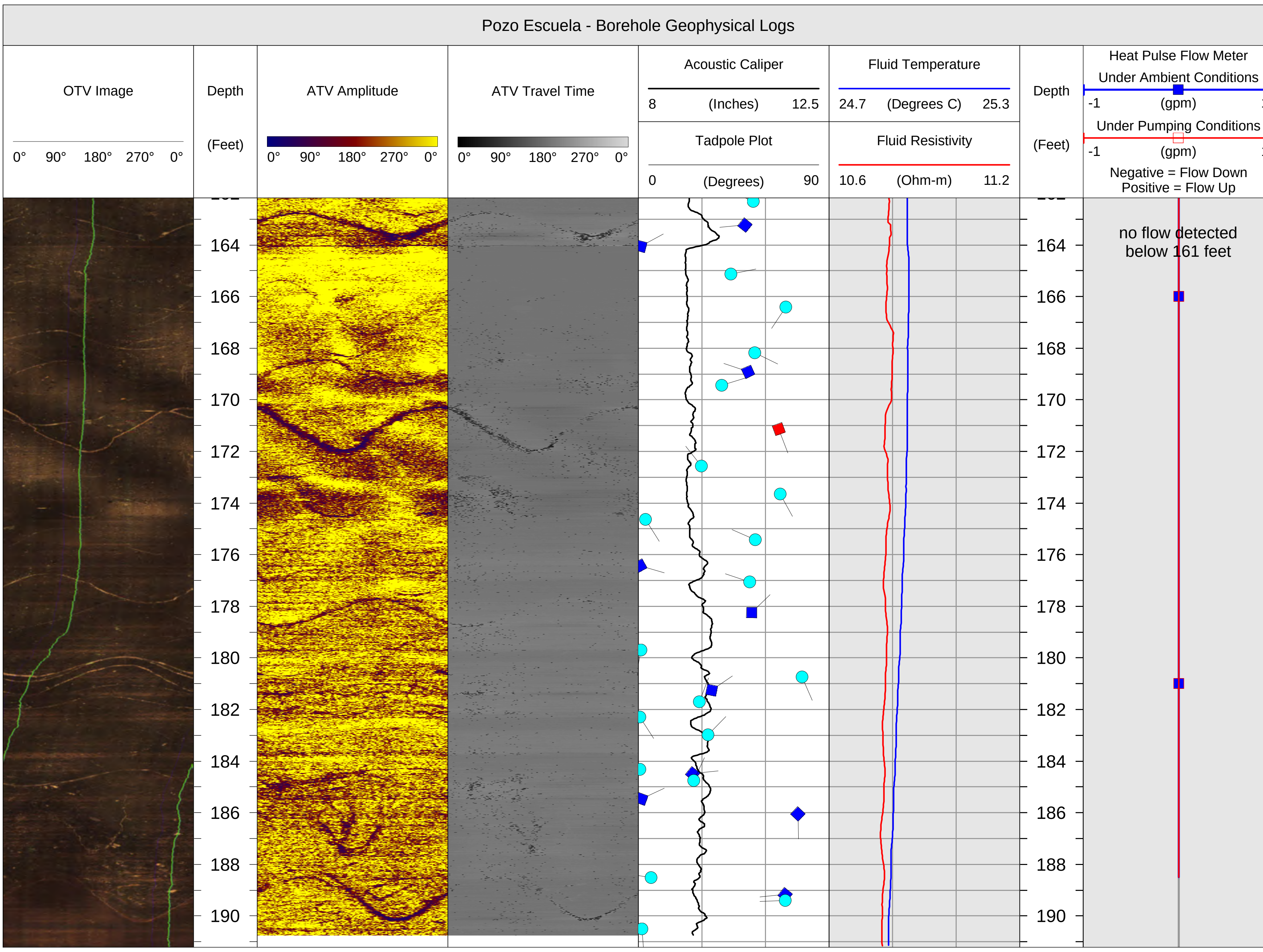
Fracture Rank 1 Fracture Rank 2 Fracture Rank 3

Pozo Escuela - Borehole Geophysical Logs





Pozo Escuela - Borehole Geophysical Logs
OTV Image
0° 90° 180° 270° 0°
Depth
(Feet)
ATV Amplitude
0° 90° 180° 270° 0°
ATV Travel Time
0° 90° 180° 270° 0°
Acoustic Caliper
8 (Inches) 12.5
Tadpole Plot
0 (Degrees) 90
Fluid Temperature
24.7 (Degrees C) 25.3
Fluid Resistivity
10.6 (Ohm-m) 11.2
Depth
(Feet)
Heat Pulse Flow Meter
Under Ambient Conditions
-1 (gpm) 1
Under Pumping Conditions
-1 (gpm) 1
Negative = Flow Down
Positive = Flow Up
92
94
96
98
100
102
104
106
108
110
112
114
116
118
120
122
124
126
128
130
132
134
136
138
140
142
144
146
148
150
152
154
156
158
160
162
flow into & up the borehole under ambient & pumping conditions
flow into & up the borehole under ambient & pumping conditions



Pozo Escuela - Borehole Geophysical Logs
OTV Image
0° 90° 180° 270° 0°
Depth
(Feet)
ATV Amplitude
0° 90° 180° 270° 0°
ATV Travel Time
0° 90° 180° 270° 0°
Acoustic Caliper
8 (Inches) 12.5
Tadpole Plot
0 (Degrees) 90
Fluid Temperature
24.7 (Degrees C) 25.3
Fluid Resistivity
10.6 (Ohm-m) 11.2
Depth
(Feet)
Heat Pulse Flow Meter
Under Ambient Conditions
-1 (gpm) 1
Under Pumping Conditions
-1 (gpm) 1
Negative = Flow Down
Positive = Flow Up
164
166
168
170
172
174
176
178
180
182
184
186
188
190
no flow detected
below 161 feet

APPENDIX 2

BEDROCK STRUCTURE STATISTICS PLOTS

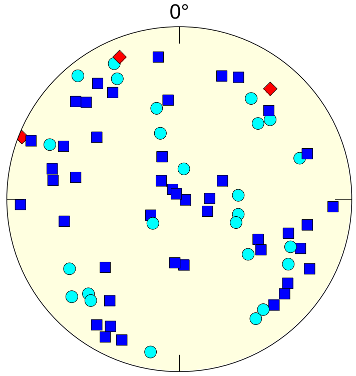
HAGER-RICHTER GEOSCIENCE, INC.	846 Main Street Fords, NJ 08863 Phone: 732-661-0555 Fax: 732-661-0123	MW-9R - FRACTURE STATISTICS PLOTS	
		DATE LOGGED:	August 19, 2013
CLIENT:	CDM Smith	H-R FILE:	13RG03
PROJECT:	Cabo Rojo Groundwater Contamination Site	ORIENTATION REFERENCE:	True North
LOCATION:	Cabo Rojo, Puerto Rico	MAGNETIC DECLINATION:	12° West

STRUCTURE LEGEND

● Fracture Rank 1 ■ Fracture Rank 2 ◆ Fracture Rank 3

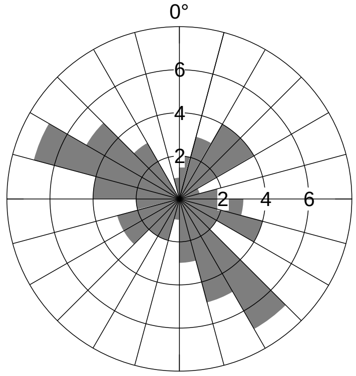
Stereogram - Lower Hemisphere of Fractures	Dip Azimuth Rose Diagram of Fractures	Dip Angle Histogram of Fractures

Schmidt Plot - LH - Bedrock Structures



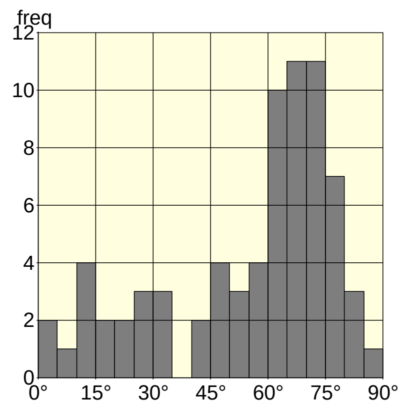
	Counts	Dip[deg]	Azi[deg]
Mean	73	55.71	189.62
●	25	55.78	264.77
■	45	54.00	118.56
◆	3	79.67	161.67

Azimuth - Absolute (Count)



Counts:	73.00
Mean:	189.62
Std.Dev.:	142.68
Min:	4.52
Max:	355.62

Dip Histogram (Count)



Counts:	73.00
Mean:	55.71
Std.Dev.:	22.38
Min:	2.93
Max:	87.98

HAGER-RICHTER GEOSCIENCE, INC.	846 Main Street Fords, NJ 08863 Phone: 732-661-0555 Fax: 732-661-0123	ANA MARIA - FRACTURE STATISTICS PLOTS DATE LOGGED: August 21, 2013

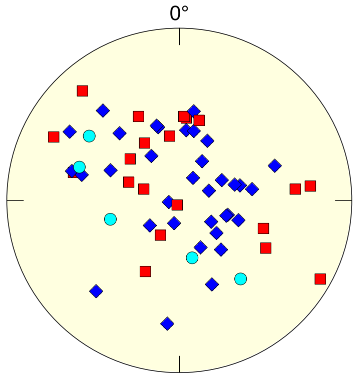
CLIENT:	CDM Smith	H-R FILE:	13RG03
PROJECT:	Cabo Rojo Groundwater Contamination Site	ORIENTATION REFERENCE:	True North
LOCATION:	Cabo Rojo, Puerto Rico	MAGNETIC DECLINATION:	12° West

STRUCTURE LEGEND

Fracture Rank 1 Fracture Rank 2 Fracture Rank 3

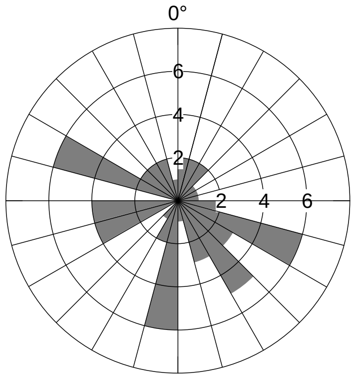
Stereogram - Lower Hemisphere of Fractures	Dip Azimuth Rose Diagram of Fractures	Dip Angle Histogram of Fractures

Schmidt Plot - LH - Bedrock Structures



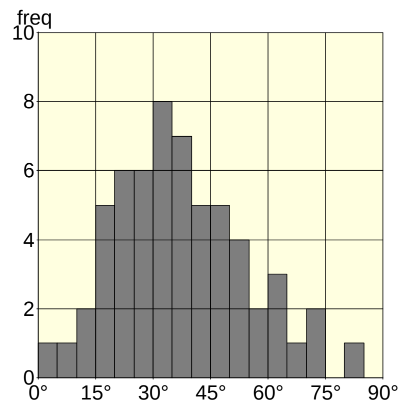
	Counts	Dip[deg]	Azi[deg]
Mean	59	37.39	180.39
■	20	42.80	150.93
◆	34	33.39	223.40
●	5	43.34	59.07

Azimuth - Absolute (Count)



Counts:	59.00
Mean:	180.39
Std.Dev.:	112.85
Min:	5.59
Max:	347.24

Dip Histogram (Count)



Counts:	59.00
Mean:	37.39
Std.Dev.:	17.13
Min:	2.68
Max:	82.78

HAGER-RICHTER GEOSCIENCE, INC.	846 Main Street Fords, NJ 08863 Phone: 732-661-0555 Fax: 732-661-0123	POZO ESCUELA - FRACTURE STATISTICS PLOTS DATE LOGGED: August 20, 2013

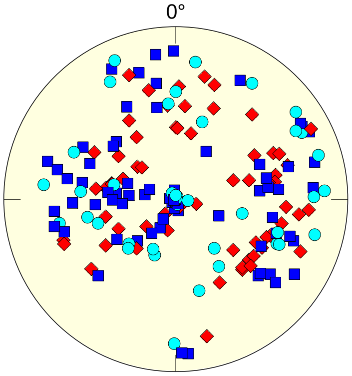
CLIENT:	CDM Smith	H-R FILE:	13RG03
PROJECT:	Cabo Rojo Groundwater Contamination Site	ORIENTATION REFERENCE:	True North
LOCATION:	Cabo Rojo, Puerto Rico	MAGNETIC DECLINATION:	12° West

STRUCTURE LEGEND

Fracture Rank 1 | Fracture Rank 2 | Fracture Rank 3

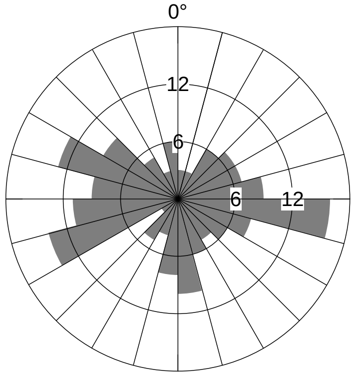
Stereogram - Lower Hemisphere of Fractures	Dip Azimuth Rose Diagram of Fractures	Dip Angle Histogram of Fractures

Schmidt Plot - LH - Bedrock Structures



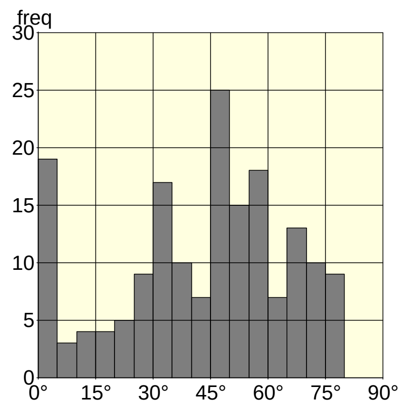
	Counts	Dip[deg]	Azi[deg]
Mean	175	43.05	198.78
◆	62	43.74	243.41
■	72	41.86	90.24
●	41	44.03	224.29

Azimuth - Absolute (Count)



Counts:	175.00
Mean:	198.78
Std.Dev.:	138.35
Min:	0.87
Max:	358.53

Dip Histogram (Count)



Counts:	175.00
Mean:	43.05
Std.Dev.:	21.91
Min:	0.57
Max:	78.91

APPENDIX 3

TABLES OF BEDROCK STRUCTURES

HAGER-RICHTER GEOSCIENCE, INC.	
MW-9R - TABLE OF BEDROCK STRUCTURES	
CLIENT	CDM Smith
PROJECT	Cabo Rojo Groundwater Contamination Site
LOCATION	Cabo Rojo, Puerto Rico
H-R FILE	13RG03
DATE LOGGED	August 19, 2013
LOG DATUM	Ground Surface (top of the concrete pad)
DIP AZIMUTH	True North (Magnetic Declination = 12° West)
DIP ANGLE	Measured from Horizontal

MW-9R - TABLE OF BEDROCK STRUCTURES

Depth (feet)	Dip Azimuth (degrees)	Dip Angle (degrees)	Bedrock Structure Category
105.2	229	60	Fracture Rank 1
106.3	251	63	Fracture Rank 1
106.4	57	65	Fracture Rank 1
106.6	301	63	Fracture Rank 1
107.1	226	53	Fracture Rank 1
109.7	285	29	Fracture Rank 1
111.1	356	32	Fracture Rank 2
111.7	115	63	Fracture Rank 2
111.9	113	71	Fracture Rank 1
111.9	11	79	Fracture Rank 1
114.0	318	71	Fracture Rank 2
114.9	141	82	Fracture Rank 1
116.9	48	73	Fracture Rank 1
118.6	164	33	Fracture Rank 1
120.3	268	14	Fracture Rank 2
120.4	173	49	Fracture Rank 2
120.6	266	28	Fracture Rank 1
122.2	44	65	Fracture Rank 1
122.8	309	43	Fracture Rank 1
123.8	154	76	Fracture Rank 1
125.3	157	79	Fracture Rank 3
125.8	166	45	Fracture Rank 1
126.5	133	72	Fracture Rank 2
126.7	327	71	Fracture Rank 1
129.2	5	31	Fracture Rank 2
129.6	145	71	Fracture Rank 2
129.8	273	78	Fracture Rank 2
130.9	293	15	Fracture Rank 2
131.6	104	65	Fracture Rank 2
133.9	148	62	Fracture Rank 2
134.5	153	68	Fracture Rank 1
135.4	136	67	Fracture Rank 2
135.7	127	50	Fracture Rank 2
137.2	287	56	Fracture Rank 2

MW-9R - TABLE OF BEDROCK STRUCTURES

Depth (feet)	Dip Azimuth (degrees)	Dip Angle (degrees)	Bedrock Structure Category
137.5	112	88	Fracture Rank 3
137.6	282	65	Fracture Rank 2
138.2	112	82	Fracture Rank 2
139.5	297	43	Fracture Rank 2
140.6	323	70	Fracture Rank 1
141.9	135	12	Fracture Rank 2
148.0	61	16	Fracture Rank 2
148.1	308	68	Fracture Rank 2
148.1	88	82	Fracture Rank 2
150.2	312	71	Fracture Rank 2
150.6	302	47	Fracture Rank 2
153.6	247	22	Fracture Rank 2
156.0	189	15	Fracture Rank 1
157.7	33	76	Fracture Rank 2
163.9	99	64	Fracture Rank 2
165.3	282	3	Fracture Rank 2
166.5	79	58	Fracture Rank 2
166.7	102	52	Fracture Rank 2
167.5	22	77	Fracture Rank 2
167.5	225	62	Fracture Rank 2
168.0	250	68	Fracture Rank 2
168.1	171	72	Fracture Rank 2
170.7	145	6	Fracture Rank 2
171.2	216	61	Fracture Rank 1
171.6	293	29	Fracture Rank 1
172.0	47	17	Fracture Rank 1
176.1	158	22	Fracture Rank 2
178.6	41	67	Fracture Rank 1
179.0	48	49	Fracture Rank 2
183.2	28	80	Fracture Rank 2
183.8	29	73	Fracture Rank 2
183.9	199	65	Fracture Rank 2
184.0	34	61	Fracture Rank 2
185.7	206	68	Fracture Rank 2
185.9	219	72	Fracture Rank 3
186.6	292	65	Fracture Rank 2
186.8	298	75	Fracture Rank 2
186.8	293	60	Fracture Rank 1
188.5	149	3	Fracture Rank 2

HAGER-RICHTER GEOSCIENCE, INC.	
ANA MARIA - TABLE OF BEDROCK STRUCTURES	
CLIENT	CDM Smith
PROJECT	Cabo Rojo Groundwater Contamination Site
LOCATION	Cabo Rojo, Puerto Rico
H-R FILE	13RG03
DATE LOGGED	August 21, 2013
LOG DATUM	Ground Surface (top of the concrete pad)
DIP AZIMUTH	True North (Magnetic Declination = 12° West)
DIP ANGLE	Measured from Horizontal

ANA MARIA - TABLE OF BEDROCK STRUCTURES

Depth (feet)	Dip Azimuth (degrees)	Dip Angle (degrees)	Bedrock Structure Category
59.2	110	26	Fracture Rank 3
59.4	264	57	Fracture Rank 3
60.7	185	40	Fracture Rank 3
61.4	138	43	Fracture Rank 2
61.4	289	43	Fracture Rank 3
62.3	154	45	Fracture Rank 3
62.6	287	24	Fracture Rank 2
63.3	338	44	Fracture Rank 2
63.9	149	32	Fracture Rank 3
64.4	183	40	Fracture Rank 3
64.9	311	23	Fracture Rank 2
65.3	320	31	Fracture Rank 2
66.0	186	34	Fracture Rank 2
66.4	43	61	Fracture Rank 2
67.3	26	38	Fracture Rank 3
68.0	190	44	Fracture Rank 2
68.5	171	31	Fracture Rank 3
69.9	192	34	Fracture Rank 2
70.7	164	37	Fracture Rank 2
72.0	163	38	Fracture Rank 2
73.1	210	22	Fracture Rank 2
73.9	194	40	Fracture Rank 3
75.4	117	71	Fracture Rank 3
76.6	139	74	Fracture Rank 3
77.9	299	83	Fracture Rank 3
78.9	264	66	Fracture Rank 3
79.8	299	48	Fracture Rank 3
80.3	80	5	Fracture Rank 2
80.7	105	54	Fracture Rank 3
82.0	250	50	Fracture Rank 2
83.1	15	11	Fracture Rank 2
83.2	288	24	Fracture Rank 2
83.8	50	19	Fracture Rank 2
84.8	289	30	Fracture Rank 2

ANA MARIA - TABLE OF BEDROCK STRUCTURES

Depth (feet)	Dip Azimuth (degrees)	Dip Angle (degrees)	Bedrock Structure Category
86.5	31	3	Fracture Rank 3
86.9	244	22	Fracture Rank 2
87.7	304	18	Fracture Rank 2
88.1	106	54	Fracture Rank 2
88.9	347	28	Fracture Rank 1
89.0	205	32	Fracture Rank 2
91.1	211	13	Fracture Rank 2
91.4	255	30	Fracture Rank 2
91.6	254	27	Fracture Rank 2
92.9	139	58	Fracture Rank 2
93.6	130	31	Fracture Rank 3
93.9	109	18	Fracture Rank 3
94.6	105	49	Fracture Rank 2
94.7	261	35	Fracture Rank 2
95.6	148	25	Fracture Rank 2
96.0	28	19	Fracture Rank 3
97.8	109	51	Fracture Rank 1
98.3	126	54	Fracture Rank 1
99.1	251	15	Fracture Rank 2
99.8	74	34	Fracture Rank 1
100.5	122	65	Fracture Rank 2
100.9	335	25	Fracture Rank 2
101.4	322	49	Fracture Rank 1
102.2	114	36	Fracture Rank 2
102.6	6	61	Fracture Rank 2

HAGER-RICHTER GEOSCIENCE, INC.	
POZO ESCUELA - TABLE OF BEDROCK STRUCTURES	
CLIENT	CDM Smith
PROJECT	Cabo Rojo Groundwater Contamination Site
LOCATION	Cabo Rojo, Puerto Rico
H-R FILE	13RG03
DATE LOGGED	August 20, 2013
LOG DATUM	Ground Surface (top of the concrete pad)
DIP AZIMUTH	True North (Magnetic Declination = 12° West)
DIP ANGLE	Measured from Horizontal

POZO ESCUELA - TABLE OF BEDROCK STRUCTURES

Depth (feet)	Dip Azimuth (degrees)	Dip Angle (degrees)	Bedrock Structure Category
39.5	241	44	Fracture Rank 3
40.8	291	49	Fracture Rank 3
41.8	76	35	Fracture Rank 3
42.6	111	27	Fracture Rank 3
42.8	317	47	Fracture Rank 3
43.3	120	46	Fracture Rank 3
44.2	283	53	Fracture Rank 3
45.3	256	36	Fracture Rank 3
46.0	256	50	Fracture Rank 3
46.4	37	9	Fracture Rank 3
46.9	175	46	Fracture Rank 3
47.7	180	35	Fracture Rank 3
48.6	134	40	Fracture Rank 2
48.8	182	55	Fracture Rank 3
49.4	203	48	Fracture Rank 3
49.7	186	45	Fracture Rank 3
50.2	199	59	Fracture Rank 3
50.6	193	62	Fracture Rank 3
51.5	274	54	Fracture Rank 3
51.9	70	59	Fracture Rank 3
51.9	260	49	Fracture Rank 3
52.3	282	10	Fracture Rank 3
52.5	182	34	Fracture Rank 3
52.8	15	15	Fracture Rank 3
53.3	251	29	Fracture Rank 3
53.7	51	54	Fracture Rank 3
55.2	95	22	Fracture Rank 2
55.4	130	24	Fracture Rank 3
56.0	30	16	Fracture Rank 2
56.3	112	45	Fracture Rank 2
57.4	127	35	Fracture Rank 3
57.9	133	22	Fracture Rank 3
59.0	290	62	Fracture Rank 2
59.6	264	41	Fracture Rank 2

POZO ESCUELA - TABLE OF BEDROCK STRUCTURES

Depth (feet)	Dip Azimuth (degrees)	Dip Angle (degrees)	Bedrock Structure Category
60.2	99	15	Fracture Rank 2
62.1	255	73	Fracture Rank 2
64.0	213	27	Fracture Rank 2
64.3	208	67	Fracture Rank 2
65.6	57	41	Fracture Rank 3
67.1	104	32	Fracture Rank 3
68.6	100	46	Fracture Rank 2
69.5	199	39	Fracture Rank 1
70.3	292	22	Fracture Rank 2
71.0	96	66	Fracture Rank 1
73.3	245	53	Fracture Rank 3
74.0	99	34	Fracture Rank 3
74.2	98	39	Fracture Rank 3
74.8	103	32	Fracture Rank 3
76.2	42	27	Fracture Rank 2
76.5	39	30	Fracture Rank 3
76.8	63	31	Fracture Rank 3
76.9	222	56	Fracture Rank 3
77.7	86	39	Fracture Rank 2
77.8	275	66	Fracture Rank 3
80.1	107	67	Fracture Rank 2
81.2	347	70	Fracture Rank 3
81.3	170	58	Fracture Rank 2
82.7	348	6	Fracture Rank 2
82.9	243	76	Fracture Rank 2
84.1	313	55	Fracture Rank 2
84.8	253	58	Fracture Rank 3
84.9	333	4	Fracture Rank 3
84.9	240	74	Fracture Rank 2
85.2	299	48	Fracture Rank 3
86.5	130	40	Fracture Rank 2
88.0	293	48	Fracture Rank 3
88.9	293	68	Fracture Rank 3
89.5	299	44	Fracture Rank 3
89.8	149	44	Fracture Rank 3
91.0	332	46	Fracture Rank 3
91.4	316	46	Fracture Rank 3
91.8	310	46	Fracture Rank 3
92.2	306	47	Fracture Rank 3
92.9	311	49	Fracture Rank 3
93.1	148	35	Fracture Rank 3
93.4	193	32	Fracture Rank 3
93.6	246	56	Fracture Rank 3
94.0	259	46	Fracture Rank 3
97.4	168	45	Fracture Rank 2

POZO ESCUELA - TABLE OF BEDROCK STRUCTURES

Depth (feet)	Dip Azimuth (degrees)	Dip Angle (degrees)	Bedrock Structure Category
97.8	166	55	Fracture Rank 3
98.6	311	37	Fracture Rank 3
98.9	188	69	Fracture Rank 1
99.8	96	29	Fracture Rank 2
100.2	242	72	Fracture Rank 1
101.1	103	31	Fracture Rank 1
101.9	299	47	Fracture Rank 2
102.1	180	53	Fracture Rank 1
102.3	1	73	Fracture Rank 1
103.0	175	47	Fracture Rank 1
103.5	345	46	Fracture Rank 1
104.5	327	38	Fracture Rank 1
105.1	239	74	Fracture Rank 2
106.2	104	60	Fracture Rank 2
108.0	308	60	Fracture Rank 2
110.0	240	69	Fracture Rank 1
110.9	172	74	Fracture Rank 2
111.4	355	79	Fracture Rank 2
111.6	96	33	Fracture Rank 2
114.0	358	78	Fracture Rank 2
114.3	284	72	Fracture Rank 1
115.9	111	14	Fracture Rank 2
116.6	254	58	Fracture Rank 2
118.1	95	46	Fracture Rank 1
119.7	169	5	Fracture Rank 2
120.0	78	59	Fracture Rank 1
121.2	253	76	Fracture Rank 1
121.8	283	33	Fracture Rank 1
122.1	136	1	Fracture Rank 2
123.1	48	19	Fracture Rank 3
124.2	13	4	Fracture Rank 2
124.5	52	3	Fracture Rank 2
125.0	213	2	Fracture Rank 1
127.1	248	44	Fracture Rank 2
128.8	263	45	Fracture Rank 2
130.9	68	59	Fracture Rank 3
131.3	74	57	Fracture Rank 2
134.3	119	52	Fracture Rank 2
136.0	101	54	Fracture Rank 2
138.2	257	45	Fracture Rank 2
138.6	338	3	Fracture Rank 1
140.3	163	66	Fracture Rank 2
140.3	359	1	Fracture Rank 2
141.3	35	20	Fracture Rank 2
142.6	302	70	Fracture Rank 2

POZO ESCUELA - TABLE OF BEDROCK STRUCTURES

Depth (feet)	Dip Azimuth (degrees)	Dip Angle (degrees)	Bedrock Structure Category
143.9	311	55	Fracture Rank 2
144.5	91	1	Fracture Rank 2
145.1	46	31	Fracture Rank 1
147.4	234	75	Fracture Rank 1
150.0	242	78	Fracture Rank 3
153.0	267	76	Fracture Rank 1
154.5	77	62	Fracture Rank 2
154.7	88	50	Fracture Rank 2
155.5	152	51	Fracture Rank 2
155.9	34	11	Fracture Rank 2
156.4	281	48	Fracture Rank 2
157.2	328	3	Fracture Rank 2
157.6	84	61	Fracture Rank 2
157.8	288	59	Fracture Rank 2
158.9	310	65	Fracture Rank 2
159.2	109	24	Fracture Rank 2
159.8	100	3	Fracture Rank 2
160.2	277	61	Fracture Rank 3
160.4	154	73	Fracture Rank 2
161.3	89	30	Fracture Rank 2
162.3	294	54	Fracture Rank 1
163.2	265	50	Fracture Rank 2
164.1	61	1	Fracture Rank 2
165.1	78	44	Fracture Rank 1
166.4	214	70	Fracture Rank 1
168.2	115	55	Fracture Rank 1
168.9	289	52	Fracture Rank 2
169.4	73	39	Fracture Rank 1
171.1	159	66	Fracture Rank 3
172.6	322	30	Fracture Rank 1
173.7	151	67	Fracture Rank 1
174.7	148	3	Fracture Rank 1
175.4	294	55	Fracture Rank 1
176.4	105	1	Fracture Rank 2
177.1	288	52	Fracture Rank 1
178.2	46	54	Fracture Rank 2
179.7	190	1	Fracture Rank 1
180.8	156	77	Fracture Rank 1
181.3	56	34	Fracture Rank 2
181.7	21	29	Fracture Rank 1
182.3	147	1	Fracture Rank 1
183.0	44	33	Fracture Rank 1
184.3	219	1	Fracture Rank 1
184.5	84	26	Fracture Rank 2
184.8	25	26	Fracture Rank 1

POZO ESCUELA - TABLE OF BEDROCK STRUCTURES

Depth (feet)	Dip Azimuth (degrees)	Dip Angle (degrees)	Bedrock Structure Category
185.5	65	1	Fracture Rank 2
186.0	179	75	Fracture Rank 2
188.5	279	6	Fracture Rank 1
189.2	265	69	Fracture Rank 2
189.4	269	69	Fracture Rank 1
190.5	176	2	Fracture Rank 1